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Labour Market Policies and Unemployment in the Presence of Search & Matching Frictions

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Table of Content

List of Figures

List of Tables

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Declaration

I declare that I am the author of this thesis and that I have consulted all the references cited. All the work of which this thesis is a record has been done by myself and has not been previously accepted for a higher degree.

George Emeka Onwordi, PhD Candidate
Date…………….

Certification

I certify that Mr. George Emeka Onwordi conducted his research under my supervision in the Department of Economic Studies, University of Dundee. Mr. Onwordi has fulfilled all the conditions of the relevant Ordinances and Regulations of the University of Dundee for obtaining the Degree of Doctor of Philosophy.

Hassan Molana, Supervisor
(Professor of Economics)
Date………….

Abstract

This thesis consists of three theoretical chapters, all related to the response of unemployment to shocks and the role of active and passive labour market policies. Throughout the thesis, unemployment is assumed to evolve as a result of the uncoordinated nature of the labour market along the lines outlined in the Diamond-Mortensen-Pissarides equilibrium search and matching model.

Chapter 2 examines the effects of employment policies on vacancy creation and allocation decisions of firms and unemployment across workers with different skills. We develop a partial equilibrium model with heterogeneous high- and low-tech jobs and with skilled and unskilled workers, which we motivate by the stark evidence on the incidence of cross-skill employment (which crowds out unskilled workers, e.g. evidence for the US, the UK and the EU put these at 58%, 32%, and 35%, respectively). We show that certain employment protection policies could, in fact, lead to a reduction in job creation and might alter the allocation of vacancies across low- and high-tech job type. We find that: (i) skilled workers benefit while unskilled workers experience high jobless rate; (ii) policy effects differ when they are skill-specific; (ii) stricter policies can have more severe consequences; and (iv) vacancy creation subsidy can play a key role in reducing unemployment across worker type as well as alleviating the cross-skill crowding out of jobs. Against conventional wisdom, we demonstrate that severance compensation can have a ‘real’ effect on job creation decision, provided there is some degree of strictness in its enforcement.

Motivated by the extensive use of fiscal stimulus policies and labour market reforms during the last economic crisis, in Chapter 3 we study the implications of labour market regulations in driving the sensitivity of an economy to fiscal spending shocks, in a Dynamic Stochastic General Equilibrium (DSGE) model with job search frictions. We demonstrate that less rigidity in the labour market reduces the impact of fiscal demand shock on job creation and employment, both at extensive and intensive margins, whereas higher rigidity amplifies it. We also establish that the extent to which government spending promotes economic activity, job creation and employment depends on the degree of substitutability between private and public consumption. Higher substitutability dampens economic activity and reduces the sizes of output and employment multipliers. Labour market-oriented fiscal spending is found to be the most potent policy instruments for promoting employment – especially in the presence of high labour market rigidities.

Finally, in Chapter 4, we study how openness to international trade and capital mobility and their interactions with labour market policies affect the behaviour of an economy, in particular with respect to its unemployment level. We show that the degree of openness to international capital flow is crucial for understanding the response of unemployment to different shocks. In isolation, by raising the incentive to invest, a reduction in capital mobility barriers leads to lower unemployment, both in the long-run and the dynamic short-run. With limited restrictions to capital movement, unemployment responds faster and with greater magnitude to a domestic productivity shock, and this is further enhanced the more the economy is open to

international trade. A striking finding of this study is that while a higher degree of capital mobility enhances the adjustment of unemployment in response to a domestic productivity shock, it dampens its adjustment to a foreign demand shock. By contrast, higher openness to international trade enhances the adjustment effects of both shocks on unemployment. Finally, we find that heterogeneity in the welfare state systems in the EU can generate substantial differentials in the adjustment of unemployment to various shocks.

Chapter 1. Introduction

This thesis consists of three theoretical chapters broadly motivated by the labour market effects, especially unemployment effects, of the global economic crisis that began in 2007, as well as the role of active and passive labour market policies in shaping these effects. More generally, we contribute to a deeper understanding of the behaviour of unemployment in the presence of labour market frictions. Below, we provide a summary of the motivation for each chapter, and the research questions addressed, the modelling strategy, main findings, and the structure of the thesis.

1.1 Motivation

Despite growing concerns about the high unemployment rates in many countries, research within policy and academic environments has paid less attention to how labour market policies drive these rates in the presence of competition for jobs. According to the OECD (2013a), *Education at a Glance 2013: OECD Indicators*, the average unemployment rate of workers with tertiary education (skilled workers) stood at 4.8 percent while that of workers without secondary education (unskilled workers) was as high as 12.6 percent at the end of 2011 across the OECD countries. These rates represent an increase of about 1.5 and 3.8 percentage points from their respective levels in 2008. While different explanations are offered in the literature for the high jobless rate, especially among the unskilled, the most widely-held view is that labour market rigidities prevent firms from adequately adjusting to accommodate new economic conditions (Bertola, Blau, & Kahn, 2001; OECD, 2004; Siebert, 1997). Thus, labour market policies aimed at promoting job creation and increasing labour market flexibility have become an important part of labour market reforms in most OECD countries (Stiglbauer, 2006).

In principle, labour market policies such as hiring or employment subsidies are thought to be the right incentives for job creation and employment, while employment protection legislations (EPL) are established to discourage inflows into unemployment by imposing statutory costs on firms anytime a worker is dismissed. The latter, which aims to protect workers and increase job stability, also serves as a disincentive for job creation, given that it lowers the expected gain from a job match. While the literature on labour market policies has focused on the effects of the fixed firing cost (‘tax’) component of EPL, that caused by severance compensation has received almost no attention, especially since the seminal work of Lazear (1990). Based on Lazear’s theoretical prediction, the justification for this is that the effects of severance on job creation can be undone via wage reduction, especially if wages are flexible. Lazear, in that study, however, empirically showed that severance lowers employment. Severance transfer remains one of the obvious manifestations of EPL, especially in the EU. As documented by Chen and Funke (2009), the standard severance compensation paid to workers for dismissal in the EU ranges from 16.0 weekly wages in The Netherlands, to 33.5 and 66.7 weekly wages in the UK and Germany respectively, to 0.00 in the US. Garibaldi and Violante

(2000) also show that severance payment constitutes approximately 90 and 88 percent of total firing costs in the UK and Italy, respectively.

A potential consequence of *intense* job competition characterising the modern labour market is the crowding out of unskilled workers. Earlier studies (for example, Dolado, Felgueroso, & Jimeno, 2000; Teulings & Koopmanschap, 1989) argue that job competition could result in skilled workers undertaking jobs with low skill requirements as a way to temporarily avoid unemployment. This, in turn, reduces the employment opportunities of the unskilled (Belan et al., 2010). In the literature, evidence of over-education – considered to be directly related to the displacement of unskilled workers by skilled ones – abounds. Hartog (2000) shows that over-education in the EU ranges between 10 and 35 percent, while in the UK and the US, Belfield (2010) and Fabel and Pascalau (2013) report it to be approximately 32 and 58 percent, respectively.[1]

In light of the above, we argue that a proper evaluation of the labour market effects of EPL requires a framework that takes into account the effects of job competition resulting from cross-skill matching, considering its role in driving the unemployment rate across skills. Thus, in Chapter 2, we study the implications of the specific aspects of active and passive labour market policies that consist of targeted severance compensation, fixed firing cost and recruitment subsidy (which are widely used in EU countries)[2] for labour market outcomes. We are particularly interested in assessing how these policies affect the vacancy creation and allocation decisions of firms, and unemployment rates across workers with different skills.

The recent global economic crisis has attracted considerable debate in the literature, both because of the suddenness in output collapse and the consequent rise in unemployment rate across countries and because of the governments' aggressive fiscal response to the crisis to stimulate aggregate demand and foster job creation. At the same time, several labour market reforms (encompassing active and passive labour market policies) have been implemented across different countries. While many recent studies have examined the effects of fiscal policies on economic outcomes, there remains little consensus on their effectiveness. This is in part due to the difficulty in isolating the *direct* effects of fiscal stimuli on economic variables (Batini, Eyraud, Forni, & Weber, 2014).

Empirical studies suggest that the degree of impact of fiscal spending depends on several factors (Blanchard & Leigh, 2013; Kwan, 2007, among others). For example, Blanchard and Leigh find that the initial level of household debt, among other variables, can significantly affect the outcomes of fiscal spending, arguing that the forecast errors at the early stage of the crisis were primarily due to poor estimation of fiscal multipliers. Kwan finds that the degree of substitutability between public and private consumptions also affects the effectiveness of

[1] More recently, ILO (2014) placed the incidence of over-education between 11.8 and 60.6 percent in Germany, 58 percent in Austria, and 28 percent in France.
[2] For instance, see Blanchard, Jaumotte, and Loungani (2013), Blanchard and Wolfers (2000), Campolmi et al., (2011a) and Garibaldi and Violante (2000, 2005).

government consumption expenditure. Labour market rigidities have also been identified as determining the size of fiscal multipliers (Auerbach & Gorodnichenko, 2013; Batini et al., 2014).

Given that most studies have focused on the output effects of fiscal policies, motivated by the above, Chapter 3 of this thesis sets out to examine the labour market effects of fiscal policies. In particular, we investigate how labour market institutions alter the structure of the economy and the channels through which this affects the transmission of fiscal policies. In contrast with many existing studies, we distinguish between traditional government consumption (which we consider to be utility-enhancing as opposed to wasteful) and labour market-oriented spending. The latter consists of job creation and employment tax subsidies (active labour market policy (ALMP) measures taken during the crisis period). A further analysis of the nature of fiscal financing instrument sheds light on the effectiveness of various fiscal stimulus policies.

Chapter 4 is motivated by increasing concerns about the effects of globalisation on the labour market (Eurofound, 2007; European Commission, 2010). A recent paper by Chowla, Quaglietti, and Rachel (2014) argues that approximately two-third of the decrease in the UK's GDP – which dropped by 7.2 percent between 2007 and 2009 – is traceable to global shock. This contraction in GDP led to the deterioration of labour market conditions, as the vacancy creation rate dropped by approximately 6 percent between the first and second quarter of 2008, and a further 22 percent by the first quarter of 2009. The unemployment rate in the UK also increased by 1.3 percentage points between the third quarter of 2008 and the first quarter of 2009 (Clancy, 2009).[3]

Given that the degree of economic openness differs for individual countries, the response of each to global developments – including those emanating from within – is likely to depend on the country's degree of openness. Gamberoni, Uexkull, and Weber (2010) showed empirically that the contractionary effect of the last economic crisis on unemployment was higher in countries with greater openness to international trade. Also, using a panel of 20 OECD countries over a 30-year period, Vallanti (2015) found that higher openness to international capital mobility increases the responsiveness of unemployment to aggregate shock.

The literature on the labour market effects of globalisation has concentrated mostly on the consequences of the 'process' of economic openness (liberalisation), paying little or no attention to how the actual degree of openness of an economy shapes its reaction to global and domestic events (e.g., Cosar, Guner, & Tybout, 2016; Du, Nie, & Wei, 2015; Felbermayr, Prat, & Schmerer, 2011; Helpman & Itskhoki, 2010). Additionally, these studies tend to separate the effects of international trade and capital mobility on the labour market, which is *not warranted* when both are key drivers of globalisation (Greenaway & Nelson, 2001; Helpman & Itskhoki, 2010), important sources of heterogeneity across countries (Antràs & Caballero, 2009), and channels through which global shocks can be transmitted to the domestic economy (Chowla et

[3] Salgado et al. (2014) provide further evidence of the variations in the labour market responses to the recent economic crisis.

al., 2014; Rodrik, 1998). Antràs and Caballero show that in the presence of international capital mobility, trade liberalisation leads to capital outflow which, as emphasised by Azariadis and Pissarides (2007), can potentially result in higher unemployment volatility. Egger, Greenaway, and Seidel (2011) also argue that while strict labour market policies lead to higher unemployment and suppress trade flow, allowing for international capital mobility can reverse these effects.

In Chapter 4, we attempt to address the following specific questions: first, what are the individual and combined effects of changes in the degree of openness to international trade and capital mobility on labour market outcomes, especially unemployment? Second, how does the degree of openness shape the transition path of unemployment in response to, for example, domestic productivity and foreign demand shocks? Third, what are the individual and joint effects of labour market reforms and economic openness on the labour market, and what role do labour market reforms and ALMPs play in determining the response of unemployment to the process of liberalisation?

1.2 Modelling Strategy

To unpack the issues addressed in this thesis, the labour market is modelled along the line outlined by the Diamond-Mortensen-Pissarides search and matching model. Credited to the early work of Diamond (1981, 1982), Mortensen (1982) and Pissarides (1984, 1985), and further advanced by Mortensen and Pissarides (1994), the search and matching model has become a central tool for the analysis of contemporary labour market issues. Unlike the standard neoclassical framework, with perfect information and no involuntary unemployment, this model focuses on market frictions and provides a basis to drive the understanding of key labour market outcomes – for example, the co-existence of vacancies and unemployment. An underlying assumption of the search and matching model is that the labour market is characterised by matching frictions, resulting from the existence of heterogeneities and imperfect information about potential 'trading partners'. Heterogeneity may arise due to the specific skills workers possess and those required by firms. Thus, unemployed workers and firms with vacancies must engage in a costly and time-consuming search process to establish employment relationships. Even when workers are identical and firms create vacancies with similar skill requirements, the absence of perfect information, e.g., about the existence and location of trading partners, implies that search must take place for employment to occur.

At any given time, the *transition* out of unemployment requires that a firm with a vacancy and a job seeker meet and agree to form a productive match. The meeting process is summarised by a matching function which maps the number of vacancies (v) and unemployed workers (u) into the number of employment relationships (matches) formed at any given time. A match is consummated if the gains from switching labour market states, thus forming a productive match, are at least greater than the values each agent would fall back to if they were to continue unmatched. Hence, job matches produce economic rents (match surplus), which are shared between firms and workers. The standard sharing rule for this rent is determined by a generalised Nash bargaining solution, which, in turn, defines the wage rate for each job. Once an employment relationship is established and the wage rate is agreed upon, production commences until the match is destroyed. Throughout this thesis, we assume that job matches are destroyed at an exogenous rate, as in Gertler, Sala, and Trigari (2008), Blanchard and Gali (2010), and Monacelli, Perotti, and Trigari (2010).

The search and matching framework has been criticised, in particular by Shimer (2005) who argued that the model lacks an internal amplification mechanism required to generate the empirically observed fluctuations in vacancy-unemployment (v/u) ratio – the so-called *Shimer puzzle*. Shimer shows that for a given labour productivity shock of a plausible magnitude, the model produces less than 10 percent of the business-cycle-frequency fluctuations in v/u ratio, because wages absorb most of the increases in labour productivity, thus reducing the procyclicality of the firm's share of the match surplus and implying lower incentive for vacancy creation. The lack of internal propagation mechanism is attributed to the surplus sharing rule implied by the Nash bargaining solution, which assigns a constant share of the match surplus to each party of a job match.

Shimer's (2005) finding has drawn significant interest in the literature, and the studies that followed proposed alternative solutions to the amplification problem. For example, Hall (2005) introduced an ad-hoc wage rigidity, where the rigidity is induced by social conventions (norm) that constrain wage adjustment for existing and newly-hired workers in response to productivity shocks, showing that this can improve the sensitivity of market variables. A Calvo-type wage stickiness was proposed by Gertler and Trigari (2008). Here, only a fraction of firms are allowed to adjust their wage in response to a positive productivity shock, while the remaining fraction pays the wage rate of the previous period. The main motivation behind this approach is that less adjustment in wage rate can increase firms' willingness to create more vacancies. However, as argued by Pissarides (2009), the wage prediction of the model matches empirical fact; instead, he shows that introducing, for instance, a fixed hiring cost can solve the Shimer puzzle. Costain and Reiter (2008) and Hagedorn and Manovskii (2008) argue that an alternative calibration to the standard model can also deliver large fluctuations in labour market variables while retaining the Nash bargaining solution.

It is worth also emphasising that the search and matching model has externalities associated with job search activities. In particular, an additional job searching unemployed worker creates positive externalises for firms with vacancies and negative externalities for other job searching workers, since it increases the vacancy filling rate of firms and reduces the rate at which workers find jobs. An additional vacancy created will have an analogous effect. As stressed by Hosios (1990) and Pissarides (2000), both the job seekers and firms ignore these externalities created by their actions, giving rise to inefficiency search. Hosios, however, showed that by equating each party's share of the joint surplus of a job match to their respective contributions to the matching is a sufficient condition under which the two opposite externalities can offset each other. This condition, which is now referred to as the *Hosios (1990) condition*, has proven to be widely applicable under different modifications to the standard search and matching model (for more discussion, see Pissarides, 2000, ch. 8).

Despite the above, the relevance and application of the search and matching have continued to grow over the past two decades – particularly in the area of addressing various labour market and macroeconomic policy questions. For instance, Cahuc and Le Barbanchon (2010) assessed the implications of counselling on the employability of unemployment workers. Belan, Carré, and Gregoir (2010) studied the effects of targeted subsidies on the employment rate of the unskilled workers. Dolado, Jansen, and Jimeno (2005) and Mortensen and Pissarides (2003), among many others, have examined the effects of EPL within search and matching framework with heterogeneous agents. The model has also been a key element of the modern monetary and real business cycle dynamic stochastic general equilibrium (DSGE) models. Using a closed economy DSGE framework with search and matching frictions, Campolmi, Faia, and Winkler (2011a) and Monacelli et al. (2010), etc. investigated the effectiveness of fiscal policies. In the context of an open economy framework, Cacciatore (2014), Felbermayr, Prat, and Schmerer, (2011), Helpman and Itskhoki (2010) and Montagna, Molana, and Onwordi (2016), among others, examined the interactions of frictional labour market and international economic openness in driving the dynamics of unemployment.[4]

Chapter 2 of this thesis builds on the Albrecht and Vroman (2002) version of search and matching model with job-worker heterogeneity, which we use to study the implications of employment policies in the presence of cross-skill matching. In this model, workers are either skilled or unskilled, and firms create vacancies with high skill (high-tech) or low skill (low-tech) requirement. Vacancy creation and their allocation into low- and high-tech job types are endogenously determined, but the distribution of workers' skills is exogenous. A central assumption of this model is that while unskilled workers possess the minimum skill required to undertake only low-tech jobs, their skilled counterparts can undertake any of the two job types. This leaves the unskilled workers competing for low-tech jobs with the skilled ones. Job creation occurs when an unemployed worker meets a firm with vacancy and they both agree to a wage. In the first part of our analysis, we assume that wages are determined through Nash bargaining solution in which both parties to a given job match maximise the joint product of the match surplus (the *flexible* wage bargaining). In the second part, this assumption is relaxed for an alternative setting where wages are taken as given when employment decisions are made (*fixed* wage). Thus, we are able to uncover the implications of various policies under the two wage scenarios, reflecting existing debates about the role of wage setting mechanism for the effects of labour market policies, especially those of severance compensation (Ahrens & Wesselbaum,

[4] See Pissarides, (2000) for the details of the equilibrium search theory; Rogerson, Shimer, and Wright (2005) for the review of search theoretic models; and Yashiv, (2007) for a recent review of the labour market search and matching theory and its applications.

2009; Garibaldi & Violante, 2000, 2005). We assess the implications of the model using both analytical and numerical solutions.

Chapters 3 and 4 develop real business cycle (RBC) DSGE models, enhanced with search and matching frictions. The DSGE models, in its modern form, evolved from the seminal paper of Kydland and Prescott (1982) who argue that an understanding of aggregate fluctuations requires the use of dynamic general equilibrium model. Concentrating on technology shock, the authors show that such dynamic model can be used to explain stylised business cycle facts. Mainly in the last two decades, accompanied by theoretical developments and computing power, DSGE models have witnessed substantial improvement and now serve as powerful tools for modern macroeconomics. The models provide a coherent platform for evaluating various questions relating to monetary and fiscal policy problems, international economics, etc., (Flotho, 2009; Negro & Schorfheide, 2013; Tovar, 2009).

The DSGE models build on microeconomic fundamentals and are dynamic in the sense that the current decisions of economic agents shape future outcomes (Sbordone, Tambalotti, Rao, & Walsh, 2010). The decision rules for these agents are derived from the assumptions about *preferences*, *technologies* and the prevailing economic policies by solving intertemporal optimisation problems. The idea of general equilibrium is based on the fact that an economy's equilibrium results from the interaction of all economic agents. In addition, the economy is modelled as being subject to exogenous shocks, such as fiscal policy, productivity, foreign demand and trade shocks – which are often assumed to follow a first-order autoregressive process (Tovar, 2009). In response to these shocks, agents optimally adjust their actions. Thus, economic fluctuations at any given point reflect the optimal reactions of economic agents. The impacts of shocks on the economy may differ, and so do their durations, depending on the long run economic structure, the source and the persistence of each shock (Wickens, 2008).

In the closed economy framework developed in Chapter 3, we assume the model consists of four economic agents: a representative household, two vertically integrated production sectors (an intermediate and final good sector) and a government. The household makes own consumption and capital accumulation decisions and supplies labour to the intermediate sector that uses both labour and capital as factor inputs in the production process. The intermediate sector is characterised by a monopolistically competitive structure in its product market and search and matching frictions in its hiring activities. To reduce the complexity of the model, we relax the assumption of job-worker heterogeneity developed in Chapter 2 and model a labour market with identical workers and firms as in Pissarides (2000). At any given time, firms create vacancies at a fixed sunk cost in order to hire workers. We assume full labour market participation, so that those who lose their jobs in any given period immediately resumes search activities for new jobs within the same period (Blanchard & Gali, 2010), rather than wait until the following period (Dabusinskas, Konya, & Millard, 2016). The final good sector operates within a perfectly competitive market and produces a final output that is used by the household and the government. The government sets rules regarding employment and has to satisfy a balanced budget. On the expenditure side, it spends on own consumptions, active labour market policies (ALMPs) and the provision of social protections for the unemployed through unemployment benefits insurance. These are, in turn, financed by revenues raised through taxes levied on labour and other household incomes and the penalties imposed on firms upon job separations. Employment is modelled to adjust along two margins, intensive (hours worked per worker) and extensive (number of workers employed), to allow for a more in-depth evaluation of the effects of government spending policies on the labour market (Yuan & Li, 2000). We also consider the possibility that the household can directly derive utility from government consumption spending as proposed by, e.g., Aschauer (1985) and Molana and Zhang (2001).

Chapter 4 considers the interactions of labour market friction and international economic openness in driving the dynamics of unemployment (Cacciatore, 2014; Felbermayr, Prat, & Schmerer, 2011; Helpman & Itskhoki, 2010; Montagna, et al., 2016). To this end, we construct a 'small' open economy DSGE model, in which the activities of the domestic agents do not influence those in the rest of the world such as the price imported varieties, foreign demand and interest rate (McCandless, 2008). Here, the setup of the domestic economy is somewhat similar to the closed economy framework in Chapter 3: the household supplies labour, consumes final good and invests in capital stock which also serves the dual function of as a productive factor and as a store of wealth. A key departure is that capital is now assumed to be internationally mobile. Also, we model a sector that acts as an intermediary between the household that supplies labour and the intermediate sector that uses the services of labour (similar to Christoffel, Kuester, & Linzert, 2009; de Walque, Pierrard, Sneessens, & Wouters, 2009). This sector is established by the government and its sole function is to hire and train unemployed workers and then sell the services of these workers as trained man-hours.[5] Exporting activities take place in the intermediate sector that produces horizontally differentiated varieties which are also sold in the domestic economy. These varieties are produced using, as factor inputs, labour services and capital. A non-traded final good is produced by the final good sector, using both imported and domestic varieties as inputs. This sector operates under a perfectly competitive structure. Both import and export are subject to an iceberg trade cost which determines the degree of openness to international trade. Capital mobility is modelled along the line proposed by Rodrik (1998).

Due to the complexity of DSGE models, which makes it difficult to obtain a closed-form solution (Fernandez-Villaverde, Rubio-Ramırez, & Schorfheide, 2016; Flotho, 2009), the analyses in both chapters 3 and 4 are based on numerical solutions.

[5] A recent evaluation of private vs public recruitment agencies in the EU show that the former provides a much more effective service delivery in terms of number of workers who exit unemployment (Behaghel, Crépon, & Gurgand, 2014). Additionally, there is marked difference between the percentage of unemployed job seekers who use private and public recruitment agencies within the EU. As suggested by the European Labour Market Survey data, provided by the Eurostat, these differences ranges from approximately 25 percent and 53 percent in the UK to 8 percent and 70 percent in Sweden for private and public recruitment agencies respectively, between the first quarter of 2008 and third quarter of 2016. (The EU-27 average over this period is reported to be 22 percent and 53 percent.)

1.3 Main Findings

In Chapter 2, we show that employment policies have different equilibrium effects on the labour market, depending on whether they are targeted towards a specific job type or are common to all jobs. Our results show that when directed towards low-tech jobs, severance compensation leads to a greater deterioration of labour market outcomes: vacancy creation rate reduces and, given its negative effect on the payoffs of low-tech jobs, existing vacancies are allocated towards the high-tech job type. In this case, the unskilled are worse off. Our numerical exercises show that in all cases, the percentage increase in the unemployment rate of the unskilled (in response to such policy change) is at least three times higher than the increase in the unemployment rate of their skilled counterparts. By contrast, severance policy directed towards high-tech jobs poses less harmful effects: they mainly influence the allocation of existing vacancies, but do not necessarily affect vacancy creation decision. Instead, an increase in such cost shifts vacancy allocation in favour of low-tech jobs due to the drop in expected gains from high-tech jobs. As a result, the unemployment rate of unskilled workers tends to reduce. Skilled workers' unemployment rate, however, remains unaffected, implying crowding out issues, since they qualify to work in any job. Fixed firing cost (assumed to be common to all job types) also adversely affects vacancy creation decision and allocation of jobs in the direction of low-tech job type. However, unlike targeted low-tech job severance compensation, the effect on the unemployment rate of the unskilled is less, even though this category of workers remains worse off compared to skilled workers. Our model predicts that vacancy creation subsidy, by reducing labour market frictions, can minimise skill crowding out in the market. We show that when wages are rigid, the sensitivity of firms to changes in labour market policies rises dramatically compared to the flexible wage case. This is because wages do not adjust to partly absorb the impact of these policies. Qualitatively, however, the results under the two wage setting framework remain the same. Finally, we establish theoretically, against conventional wisdom, that severance compensation has a 'real' impact on labour market outcomes, even when wages are flexible, as long as there is strict enforcement.

In Chapter 3, we examine the long-run implications of individual policy instruments to identify the channels through which they affect an economy. We find that through their effects on hiring cost, ALMPs improve economic activity, whereas higher labour market rigidities (in the form of unemployment insurance benefits, distortionary labour tax and firing penalty that incorporates a fixed firing cost and severance transfer to workers) reduce it. We also find that the effectiveness of government consumption spending depends on the degree of substitutability between private and government consumption. Specifically, when associated with a higher weight in the household utility, the impact of a rise in government consumption spending on aggregate demand and job creation reduces. This is because, by raising private utility, the household spend less on consumption as government spending rises. Thus, the increase in the latter is partly offset by the decrease in the former, reducing the impact on aggregate demand as well as the incentives for hiring.

We argue that if labour market institutions are rigid, the incentives to create vacancies and supply more hours to work per employee are enhanced in response to government consumption expansion. The key mechanism underlying this result is the effects of these institutions on the long-run sizes of the match surplus and the household disposable income (HDI). By raising labour cost, rigid labour market regulations reduce match value and, by subsequently reducing employment and productivity they, lead to a lower HDI in the long-run, making both firms and households more sensitive to shocks. The influence of match surplus on the dynamics of job creation has been emphasised by a number of studies in the literature in the context of productivity shock (Hagedorn & Manovskii, 2008; Hornstein, Krusell, & Violante, 2005; Shimer, 2005). We find a similar mechanism at work in the case of government consumption spending shock. The intuition is that, when the size of match surplus is small, a positive shock, which raises productivity, leads to a larger percentage increase in the values of a match. Therefore, firms adjust to shocks through rapid vacancy creation, which translates into a stronger response in employment at the extensive margin. For the household, the anticipation of further tax obligations resulting from increased government consumption spending leads to a greater downward adjustment in private consumption. This, in turn, induces a stronger increase in the supply of hours of work per employed worker. In this case – even though the response of capital is dampened – output level is sustained by stronger aggregate hours response.

Finally, given that the nature of fiscal offsetting instruments plays a key role in determining the effectiveness of fiscal stimulus spending (Baxter & King, 1993), we examine the effects of lump-sum tax vs. distortionary tax financing options. Our result suggests that only labour market-oriented fiscal policies remain effective in generating more jobs, regardless of the financing option. Government consumption spending produces negative output and employment responses when financed by a distortionary tax, resulting in negative multiplier effects. We find that even when the offsetting instrument is the traditional lump-sum tax, the computed output and employment multipliers of government demand stimulus remain largely less than one (as has been observed by, e.g., Campolmi et al., 2011a; Cantore, Levine, & Melina, 2014). The multiplier effects produced by employment tax subsidy are also small, but unlike the demand stimulus, the effects on job creation and employment are positive when it is distortionary tax-financed. Only the recruitment subsidy is able to generate a positive output and employment multipliers that are above one in the presence of labour market rigidities and irrespective of the financing instrument.

In Chapter 4, we demonstrate the importance of openness to international capital mobility and trade on the dynamics of unemployment. We find that, by raising the incentive for investment, a reduction in capital mobility barrier leads to a lower unemployment, both in the long-run and the dynamic short-run. Two driving forces are identified: the first is what we refer to as the *domestic demand effect*, and the second, the *wealth effect*, through HDI. We argue that provided capital is accumulated in the domestic economy, an increase in investment resulting from a sudden increase in openness to capital mobility will lead to higher domestic demand for intermediate products. This, in turn, raises labour productivity and leads to higher recruitment and lower unemployment. In the second case, as the domestic capital accumulation rises, the incipient decrease in the domestic interest rate forces the household to invest excess capital abroad. The receipt on net capital flow, therefore, boosts the household's wealth, thereby encouraging further investment and consumption. As for the effects of international trade openness, we find that, by increasing foreign demand for domestic varieties, and consequently labour productivity, a reduction in trade barrier leads to lower unemployment. Our model predicts that, compared to the individual cases, a joint reduction in international capital mobility and trade barriers can deliver greater benefits in terms of increased hiring activities and lower unemployment.

Regarding the effects of degree of openness on the response of unemployment to shocks, we find that a higher degree of openness to international capital mobility leads to an enhanced adjustment in unemployment in response to domestic productivity shock, resonating with the empirical findings obtained by Vallanti (2015). Azariadis and Pissarides (2007) have also shown, using a one-sector equilibrium life-cycle framework characterised by search and matching frictions and international capital mobility, that this result holds theoretically. Our model, however, predicts that an increase in the degree of trade openness can further enhance the adjustment of unemployment in terms of the peak effects. A compelling result from our numerical evaluations is that shocks originating from different sources are likely to lead to different dynamics in the adjustment of unemployment, depending (especially) on the initial degree of access to the international capital market. In particular, we find that while a higher capital mobility enhances the response of unemployment to a positive domestic productivity shock, it weakens the response to a positive foreign demand shock. By contrast, a lower barrier to trade magnifies the effect of both shocks on unemployment: both the speed of initial adjustment and the peak effects are enhanced.

Finally, this chapter also shows the relevance of labour market reforms and ALMPs on the dynamic response of unemployment. Individually, each labour market reform (a reduction in firing penalty or unemployment benefits) and ALMP (job creation or training subsidy) results in a lower unemployment by encouraging more recruitment activities. However, when accompanied by a higher degree of openness to foreign trade or capital mobility, the combined effects deliver larger benefits to the economy in terms of lower unemployment than when implemented individually in the steady state. We further examine the dynamic adjustment of unemployment under different labour market reforms packages, which we calibrated to reflect the labour market features of three known welfare systems in the EU countries: the *flexicurity*, *liberal* and *Mediterranean* welfare systems. Our results show that heterogeneity in the welfare systems can generate substantial differentials in the adjustment of unemployment to various shocks. Whilst the welfare systems characterised by greater flexibility in hiring and firing rules (the flexicurity and liberal systems) tend to exhibit larger unemployment fluctuations, those with stricter employment rules (the Mediterranean system) tend to experience slower and protracted response in unemployment to shocks.

1.4 The Structure of this Thesis

The remainder of this thesis is organised into four chapters and is presented such that Chapters 2, 3 and 4 can each be read independently if desired without any serious loss of continuity.

Chapter 2 (Job Competition, Vacancy Creation and Labour Market Policies) considers an extended version of the Albrecht and Vroman (2002) search and matching model. In this chapter, we study the behaviour of the labour market, concentrating on how labour market policies shape firms' vacancy creation and allocation decisions as well as affect unemployment rates of skilled and unskilled workers.

Chapter 3 (Fiscal and Labour Market Policies in a General Equilibrium Model with Search and Matching) develops a closed economy DSGE model to examine the effects of fiscal stimuli on the labour market. We consider the influence of labour market rigidities in shaping the propagation mechanisms of fiscal shocks as well as the effects of alternative forms of fiscal stimulus policies on the dynamics of the labour market.

Chapter 4 (Unemployment Dynamics and Economic Openness to International Trade and Capital Mobility) constructs a small open economy DSGE model, where the economy is assumed to interact with the rest of the world through trade in intermediate goods and capital mobility. Here, we study the effects of economic openness on unemployment dynamics. We also consider the possible labour market effects of the current reform drive towards a *flexicurity* welfare system in the EU in the presence of economic openness.

Chapter 5 (Conclusion) summarises and concludes the thesis by recapitulating the research strategy and main findings from each chapter. Research limitations and areas for possible extensions are discussed here.

Chapter 2. Job Competition, Vacancy Creation and Labour Market Policies

2.1 Introduction

Despite growing concerns about the high unemployment rates in many countries, research within policy and academic environments has paid less attention to how labour market policies drive these rates in the presence of competition for jobs. According to the OECD (2013a), *Education at a Glance 2013: OECD Indicators*, the average unemployment rate of workers with tertiary education (skilled workers) stood at 4.8 percent while that of workers without secondary education (unskilled workers) was as high as 12.6 percent at the end of 2011 across OECD countries. These rates represent a rise of about 1.5 and 3.8 percentage points from their respective levels in 2008. Equally striking is that between 2008 and 2013 the percentage increase in the unemployment rate of the unskilled was roughly four times greater than the increase of the skilled workers' unemployment rate, within the EU countries (Bjørsted, 2014). While different explanations are offered in the literature for the existence of the high jobless rate, especially among the unskilled, the most widely-held view is that labour market rigidities prevent firms from adequately adjusting to accommodate new economic conditions (Bertola et al., 2001; OECD, 2004; Siebert, 1997). Thus, policies aimed at eliminating firing restrictions (Employment Protection Legislations (EPL)), introducing active labour market policies such as recruitment and training subsidies, reducing unemployment benefit insurance, etc., have been high points of the recent reform agenda towards improving the functioning of the labour market in most countries, especially those within the OECD/EU (Stiglbauer, 2006).

In principle, labour market policies such as recruitment subsidies are thought to be the right incentive for job creation and employment, while EPL is established to discourage inflows into unemployment by imposing statutory costs on firms anytime a worker is dismissed. The latter, which aims to protect workers and increase job stability, also serves as a disincentive for job creation, given that it lowers the expected gain from a job match. While the literature on labour market policies has focused on the effects of the fixed firing cost ('tax') component of EPL, that caused by severance compensation has received almost no attention, especially since the seminal work of Lazear (1990). Based on Lazear's theoretical prediction, the justification for this is that the effects of severance can be undone via wage reduction, especially if wages are flexible, and thus, its impact on firms' vacancy creation decision is neutral. However, in that study, Lazear empirically show that severance lowers employment. Severance transfer remains one of the obvious manifestations of EPL, especially in the EU. As documented by Chen and Funke (2009), the standard severance compensation paid to workers upon dismissal in the EU range from 16.0 weekly wages in The Netherlands, to 33.5 and 66.7 weekly wages in the UK and Germany respectively, to 0.00 in the US. Even more striking is the fact that severance payment constitutes a large proportion of firms' total firing costs in most EU countries; approximately 90 and 88 percent in the UK and Italy, respectively (Garibaldi & Violante, 2000). Goerke and Pannenberg (2010) also suggest that severance payment to workers induces additional burden to the firing firm. For instance, a firm may incur additional legal cost in the course of implementing or negotiating the final value of severance compensation with the worker.

In this chapter, we study the labour market effects of specific aspects of active and passive labour market policies that consist of targeted severance compensation, fixed firing cost and recruitment subsidy (which are widely used in EU countries).[1] In particular, we argue that a proper evaluation of the effects of these policies on the labour market requires a framework which takes cross-skill matching into account, considering its role in driving the employment outcome of different categories of workers.[2] A potential consequence of intense job competition characterising the modern labour market is the crowding out of the unskilled workers, i.e., a situation where skilled workers undertake jobs with low skill requirements, thus weakening the employment opportunities of unskilled workers (Belan et al., 2010). This phenomenon is mostly associated with job competition between workers with various skill levels and is often a consequence of high unemployment. As documented by Dolado et al. (2000) and Teulings and Koopmanschap (1989), the higher the proportion of skilled workers searching for jobs or the intensity of job competition at any given time, the higher the number of such workers who end up in low-tech jobs. Dolado et al. (2000, 2009) further argue that this phenomenon is often the best way for skilled workers who temporarily want to exit unemployment and then search for a better paying job in the future.

Evidence of over-education, assumed to be directly related to the displacement of unskilled workers by skilled ones or skill mismatch, abounds.[3] Among other studies, Hartog (2000) reports the evidence of over-education in the EU to be in the range between 10 and 35 percent, while in the US and the UK, Fabel and Pascalau (2013) and Belfield (2010) report it to be approximately 58 and 32 percent, respectively. Accounting for the possibility of mismatch/cross-skill matching is important, especially when evaluating the implications of targeted labour market policies/reforms. As stressed by Belan et al. (2010), reforms aimed at reducing the unemployment rate of unskilled workers may be undermined if the targeted group of workers is crowded out by another group of workers. For instance, if the government reduces the statutory compensation on jobs with low skill requirement in order to improve the employment outcome of unskilled workers, the existence of unemployed skilled workers who are willing to undertake such jobs could crowd out the unskilled workers due to job competition. Even when policies are common to jobs (irrespective of their skill requirement), the possibility of cross skill-matching implies that such policies are likely to have different implications

[1] See Blanchard, Jaumotte, and Loungani (2013), Blanchard and Wolfers (2000), Campolmi, Faia, and Winkler (2011) and Garibaldi and Violante (2000, 2005).

[2] Cahuc and Barbanchon (2010) show that policy evaluations neglecting the spill-over effects on non-targeted individuals and other equilibrium outcomes can lead to erroneous policy design.

[3] See, for example, Belan et al. (2010), ILO (2014) and McGuinness (2006). Other examples include Dolado et al. (2000, 2009), who document evidence of over-education and crowding out in Spain, and Dolton and Vignoles (2000) and Dekker, de Grip, and Heijke (2002) for the evidence in the UK and Belgium respectively. ILO (2014) also has a recent report of the incidences over-education as a percentage of employment across EU countries.

(quantitatively) on vacancy creation and employment outcomes of skilled and unskilled workers.

A number of theoretical papers have examined the effects of different aspects of labour market regulations using heterogeneous agents' framework in the spirit of the Diamond (1982), Mortensen (1982) and Pissarides (1985) search and matching model. This is driven by the fact that, compared to the homogenous agent framework, models with heterogeneous agents more realistically capture empirical stylised facts about the labour market. Acemoglu (2001) investigate the effects of unemployment benefits and minimum wage regulations on vacancy creation decisions of firms in a model with heterogeneous high- and low-tech jobs[4] The author shows that, by raising their outside option (reservation wage), unemployment benefits make workers less willing to accept low-tech jobs, given that such jobs pay lower wage rate, thus forcing firms to create more high-tech vacancies. Also, by making low-tech jobs less profitable, minimum wage regulations have a similar effect on vacancy allocation decisions of firms. The key drawback of this framework, however, is the assumption of homogeneity in workers' skills, which ignores the equilibrium effects of workforce skill composition on firms' vacancy allocation decision. Dolado, Jansen, and Jimeno (2005) introduce worker-side heterogeneity to examine the labour market effects of targeted firing cost policy but assumes identical firms, which is somewhat unappealing since all workers are suitable for the same job, irrespective of their skills. A two-sided heterogeneous search and matching framework was considered by Mortensen and Pissarides (2003) in their study which looks at the labour market implications of taxes and subsidies. In that model, the labour market is completely segmented in the sense that unskilled workers match only with low-tech jobs, while their skilled counterparts match only with high-tech jobs. Thus, except for their connection through government budget constraint, the employment outcomes of skilled and unskilled workers are independent of each other, given *directed* job search activities and the absence of cross-skill matching.

This chapter contributes the literature by examining the influence of labour market policies on vacancy creation and allocation decisions of firms, and unemployment rate across workers with different skills. Different from the above studies, we build on the Albrecht and Vroman's (2002) (henceforth, AV-02) search and matching model with two-sided heterogeneity as well as cross-skill matching, which captures the effects of crowding and job competition. In this framework, workers differ with respect to their skills (skilled and unskilled), and the distribution of these skills is exogenous. Firms create vacancies with either low skill (low-tech) or high skill (high-tech) requirements. A fundamental assumption of this model is that skilled workers can undertake both high- and low-tech jobs, but unskilled workers can undertake only low-tech jobs. Thus, the labour market is such that unskilled workers compete for low-tech vacancies with the skilled ones, capturing empirical stylised facts, for example, Abrassart (2015). As in the standard model, each employment relationship creates economic rent, which is divided via Nash bargaining rule between the worker and the employer, and breaks up exogenously. We

[4] Note that the author refers to this as 'good' and 'bad' jobs.

assume that each firm faces a firing cost, which (in order to account for a comprehensive form of EPL measure) is modelled to consist of procedural costs – such as notice period requirements, administrative and legal expenses – and severance payment costs. The latter is assumed to be job specific; this way, we are able to associate each job type with different level of firing cost. We also assume that firms receive subsidy aimed at reducing friction introduced by job creation cost

We demonstrate that employment policies have different equilibrium effects on the labour market, depending on whether they are targeted towards a specific job type or common to all jobs. We also show, against conventional wisdom, that severance compensation has a real impact on labour market outcomes, even when wages are determined via Nash bargaining, as long as there is strict enforcement. In particular, our results indicate that when directed towards low-tech jobs, severance compensation leads to a greater deterioration of labour market outcomes: vacancy creation rate reduces and, given its negative effect on the payoffs of low-tech jobs, allocation of vacancies are shifted towards the high-tech jobs and away from low-tech jobs. In this case, the unskilled are worse off: their job finding rate drops significantly, leading to a rise in the unemployment rate. Our numerical exercises show that in all instances, the percentage increase in the unemployment rate of the unskilled (in response to such policy change) is at least three times more than the increase in the unemployment rate of their skilled counterparts.[5] By contrast, when directed towards high-tech jobs, severance compensation has less harmful effects, mainly influencing the allocation of vacancies. Specifically, an increase in such costs shifts vacancy allocation in the direction of low-tech job type because the profitability of high-skill jobs is reduced. As a consequence, the unemployment rate of unskilled workers tends to reduce, whereas that of skilled workers remain stable since they qualify to work in any job type. Thus, rather than have a much more favourable impact in lowering unskilled workers’ unemployment rate, this result suggests some crowding out issues in the presence of cross-skill matching, resonating with the empirical findings documented by Abrassart (2015) and Pollmann-Schult (2005).

Furthermore, we find that fixed firing cost, assumed to be common to all job types, also adversely affects vacancy creation activities and the allocation of vacancies towards low-tech job type. However, unlike targeted low-tech job severance compensation, the effect on the unemployment rate of the unskilled is less, although this category of workers remains worse off compared to skilled workers. Our model predicts that vacancy creation subsidy can be an effective way of reducing unemployment problems. The immediate impact of an increase in subsidy is to reduce the cost of vacancy creation and increase the market tightness. In terms of its effect on the allocation of vacancies, we find that the subsidy leads to the allocation of vacancies away from low- towards high-tech vacancies, since all else equal, the latter is more

[5] The fact that policies directed towards low-tech jobs play a crucial role is instructive considering that small businesses play a crucial role in the area of job creation and accounts for a large proportion of the firms in many countries. For instance, in the OCED, the Small and Medium-sized businesses account for about 60 to 95 percent of firms and provides approximately 70 percent of total employment in the labour force (OECD, 2000, 2013b).

profitable. However, given that an increase in the fraction of high-tech vacancies raises the arrival rate of such vacancies to skilled workers, vacancy creation subsidy leads to a reduction in the competition for low-tech vacancies; consequently, reducing the unemployment rates across skills, due to the ease of finding jobs.

Finally, given that the above results are obtained in a system where wages are bargained between agents to the job match, we compare the effects of the same set of policies with the case where the wages are predetermined (rigid). As documented by Garibaldi and Violante (2000), severance *neutrality* effect fails to hold if firms are unable to transfer (or share) the cost imposed by severance compensation to the workers through wage cut. This implies that severance cost itself has a real effect on firms' vacancy creation and allocation decisions, which in turn affects unemployment rate and other labour market indices. Our simulations suggest that firms become much more sensitive when wages are predetermined than when they are allowed to negotiate with workers; even a small change in policy can trigger a dramatic adjustment in vacancy creation activities.

This study closely relates to Burda (1992) and Millard and Mortensen (1997) in terms of severance policy consideration. In particular, Burda assumes that a worker receives severance compensation upon dismissal, while the firm incurs a fixed firing cost. In that study, severance compensation per se has no influence on labour market outcomes; rather, it is the difference between a firm's fixed firing cost and the severance compensation that drives the behaviour of firms and the resultant effects on the overall market. He shows that when the difference is positive, an increase in job destruction rate leads to an increase in unemployment and a decrease in market tightness (the vacancy-unemployment ratio). The opposite holds when the difference is negative. In other words, when the fixed firing cost and severance are equal, the unemployment rate and the degree of market tightness are unaffected. By contrast, Millard and Mortensen demonstrate that severance compensation directly weakens the firm's bargaining position, which in turn increases the wage rate paid to workers. The resultant increase in wage rate then induces firms to scale back vacancy posting. Though these authors evaluated firing costs and vacancy creation subsidy as we do, both studies are developed in identical worker-firm framework.

By considering heterogeneity in workers' skill and firing costs, this study also relates to Mortensen and Pissarides (2003) and Dolado et al. (2005). However, as suggested above, these studies do not incorporate the severance transfer component of firing cost. Moreover, the presence of cross-skill employment differentiates this study from theirs. In terms of framework, this paper complements Belan et al. (2010), but the objective of that paper differs from ours; specifically, the authors concentrate on the effects of targeted low-tech job subsidies. Furthermore, their model assumes that low-tech jobs pay minimum wage, whereas we allow for bargained wage.

The rest of this chapter is organised as follows: Section 2.2 sets out the model and discusses the conditions necessary for the existence of cross skill matching equilibrium. Section 2.3 examines the qualitative implications of policies. In Section 2.4 we evaluate the model quantitatively. The calibration strategy and the numerical solutions are discussed in this section. Section 2.5 considers the framework with predetermined wage and compares its outcomes with those obtained from flexible wage model. Finally, in sections 2.6 and 2.7, we respectively carry out robustness checks of the model's results and conclude the chapter by providing a summary of the model and the main findings.

2.2 The Model

This section sets up the AV-02 partial equilibrium search and matching framework with heterogeneous jobs and workers, extended to account for the effects of labour market policies. The labour force is normalised to one, and workers are either skilled or unskilled with the distribution of these skills exogenously determined. Firms create vacancies with high skill (high-tech) or low skill (low-tech) requirements. The model is specified in continuous time, and job search is assumed to be undirected.[6] The latter implies that both skilled and unskilled workers can encounter any of the two vacancy types offered in the market. However, due to the minimum skill requirement for high-tech vacancies, an encounter with an unskilled worker cannot crystallise into a productive match. A skilled worker, however, can be matched with any job type, provided it is beneficial to do so. A job match is established when a firm with a vacancy meet with an unemployed worker, and both agree to a wage rate, determined through Nash Bargaining solution. Matches are dissolved at an exogenous rate, and each firm is subject to a firing cost consisting of a fixed separation cost and severance compensation, but receives a subsidy towards vacancy creation. In what follows we consider the setup environment which characterises search and matching frictions.

2.2.1 The Set-up Environment

Consider a labour market that is populated by a continuum of heterogeneous workers with measure normalised to one and a large continuum of identical firms. For tractability, and in line with AV-02, all agents are assumed to be infinitely-lived,[7] risk-neutral and to discount their future at a common risk-free interest rate, $r > 0$.[8] Workers are either skilled (h) or unskilled (l). The fraction of the unskilled in the labour force is denoted by $p \in (0,1)$, while the remaining fraction, $1-p$, are skilled workers. The distribution of these skills is assumed to be exogenous.

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[6] Models with directed search (*competitive search equilibrium*), pioneered by Moen (1997), have to some extent also received attention in the literature. The key difference between the undirected and directed search models is that the latter assumes that wages are posted by *market markers* operating within submarkets and agents direct their search activities to the markets which offers the best payoffs. However, as highlighted earlier, the wage setting mechanism in the latter via a decentralised Nash bargaining.

[7] The assumption of infinitely lived agents is useful for simplifying analyses because it avoids having to treat each generation of workers and firms differently. In most economic models, this assumption is frequently justified based on *altruistic* reasons, as reflecting the fact that agents care about future generations. As pointed out by Herzberg (2015, p. 25), the main drawbacks associated with finite time horizon models is that solutions to such models depend on the assumed terminal date, which is often unrealistic. Moreover, it can be shown (e.g. Krusell, 2014, p. 50) that if a terminal date is long enough, solutions to finite time horizon converge to those of infinite time models.

[8] For a model with risk-averse agents see, e.g., Acemoglu and Shimer (1999).

We abstract from flow into and out of the labour force, and instead assume that workers are either employed or unemployed.

Jobs are either filled or vacant and are differentiated by their own skill requirements: high skill (high-tech) or low skill (low-tech) jobs. We use the index $j, j = n, s,$ to distinguish the two types of jobs: low-tech (n) and high-tech (s). A key assumption in this model is that skilled workers can undertake either of the two job types, whereas unskilled workers are only suitable for low-tech jobs. We also abstract from on-the-job search, implying that a skilled worker employed on a low-tech job (mismatched worker) cannot search on-the-job for high-tech jobs. As in Dolado et al. (2009) and AV-02, all workers employed on low-tech jobs produce the same amount of output, irrespective of their skill level, but skilled workers produce a higher output when matched with high-tech vacancies.[9]

More formally, let $x_i^j = y^j$ denote the output of a job match between a worker of type $i, i = l, h$ and a job of type $j,\ j = n, s$, the specific match productivity can be summarised (as shown in Table 2.1 in Appendix 2) as follows. A match between an unskilled worker (type l) and a low-tech job (type n) produces a flow output, y^n . Due to the assumption above, a skilled worker (type h) who matches with a low-tech (type n) also produces a similar flow output, y^n, as their unskilled counterpart. However, when matched with a high-tech (type s) job, a skilled worker produces y^s. Since unskilled workers do not have the relevant skills required to undertake high-tech jobs, $x_l^s = 0$. Consequently, $y^s > y^n > 0$.

Labour market frictions imply that both unemployed workers and firms with vacancies must engage in a time-consuming and costly search process in order to establish employment relationships. Job search is *undirected*, which implies that an unskilled worker can encounter either a low- or high-tech vacancy, but only a meeting with the former can translate into a productive match. A skilled worker, however, can become matched with any job type. The aggregate matching rate per unit of time is governed by a matching function, given by $m(u, v)$, where u and v respectively denote unemployment rate and a measure of vacancies. The function $m(.,.)$ is conventionally assumed to be concave, increasing in each argument and to be homogenous of degree one (Yashiv, 2007).[10] Defining $\theta = v/u$ as a measure of the degree of labour *market tightness*, the homogeneity assumption of the matching function implies that a firm's vacancy filling rate can be defined as $q(\theta) \equiv \frac{m(u,v)}{v} = m(\theta^{-1}, 1)$. The corresponding rate at which an unemployed worker meets with a firm with a vacancy, the job finding rate, is given

[9] As pointed out by Dolado et al. (2009), one of the main reasons that a mismatch of this form can occur is that skilled workers may want to temporarily exit unemployment by accepting low-tech job and then search on the job. For simplicity, however, we do not consider this option. Additionally, in the one-sided heterogeneous workers' model developed by Dolado et al. (2005), workers are assumed to have different productivity levels on the same. The *technology* assumed in our model is such that the outputs of workers do not differ when hired on the same job.

[10] Note that *essentiality* condition is assumed in the sense that a strictly positive amount of each input is required for a job match to occur $m(0,0) = m(0, v) = m(u, v) = 0$.

by $\theta q(\theta) \equiv \frac{v}{u}\frac{m(u,v)}{v}$. The standard Inada-type condition is assumed so that $\lim_{\theta\to\infty}\theta q(\theta) = \lim_{\theta\to 0} q(\theta) = \infty$ and $\lim_{\theta\to 0}\theta q(\theta) = \lim_{\theta\to\infty} q(\theta) = 0$. Given the constant search intensity implied by the matching function[11] and the fact that not all job search encounter result into a productive match, it is useful to define the following effective meeting rates. Let ϕ denote the fraction of low-tech vacancies and $1-\phi$ the fraction of high-tech vacancies, the effective job finding rate for an unskilled unemployed worker is given by $\phi\theta q(\theta)$. In a similar fashion, let the fraction of unemployed skilled workers be denoted by $1-\gamma$, where γ denotes the share of unskilled workers in the pool of unemployed. The effective rate at which a firm with high-tech vacancy meets a skilled worker is given by $(1-\gamma)q(\theta)$.[12]

2.2.2 Match Surplus and Value Functions

Job matches between unemployed workers and firms with vacancies are consummated whenever the surplus associated with the match is nonnegative. This requires that the respective gains from switching labour market state must at least greater than what each party to the job match would gain if they were to continue unmatched. Let U_i and W_i^j denote the respective value of unemployment and employment to a worker of type $i, i = l, h,$ when unemployed and when matched with a vacancy of type $j, j = n, s$. Similarly, let the value of a vacancy of job type j be denoted by V^j, and the corresponding value of having that vacancy filled with a worker of type i be given by J_i^j. The necessary condition for the realisation of a job match is

$$S_i^j \equiv \left(J_i^j - V^j\right) + \left(W_i^j - U_i\right) \geq 0; i = l, h; j = n, s, \tag{1}$$

where S_i^j represents the surplus of a job match, given by the sum of the respective *capital* gains accrued to the firm and to the worker for switching labour market state; i.e. $J_i^j - V^j$ and $W_i^j - U_i$.[13]

When unemployed and searching for a job, a worker enjoys an instantaneous value of leisure, $b > 0$. b can be thought as unemployment insurance benefits or value of home production. Following Gautier (2002) and Mortensen and Pissarides (2003), we assume b is exogenously determined and common to all unemployed workers, irrespective of their skill type.

[11] Note that with search intensity, s, the matching function can be modelled as $m(su, v)$ – see, Yashiv (2007). For simplicity, we assume $s = 1$.

[12] In order to maintain a consistent presentation style (similar to those found in Pissarides, 2000) throughout this thesis, we differ slightly from those used in AV-02. The properties of the matching function, job finding and vacancy filling rates are, however, the same.

[13] This expression follows many of the conventions in search-matching model, for instance, Burda (1992), Millard and Mortensen (1997), Pissarides (2000), Mortensen and Pissarides (2003), Dolado et al. (2005) and Boeri (2011). The current specification resembles that of Burda (1992) in the sense that we do not include any of the policy instrument in the surplus equation. Generally, the inclusion of a policy instrument, such as the firing costs, in the surplus equation means that the burden of such cost is shared directly by both workers and firms whether or not matches are eventually consummated (Dolado et al., 2005; Ljungqvist & Sargent, 2016).

The flow values of unemployment of an unskilled and a skilled worker satisfy the following Bellman equations,

$$rU_l = b + \theta q(\theta)\phi(W_l^n - U_l) \tag{2}$$

and

$$rU_h = b + \theta q(\theta)\{\phi \max(W_h^n - U_h, 0) + (1-\phi)(W_h^s - U_h)\}. \tag{3}$$

For an unskilled worker, equation (2), the flow value of unemployment equals the unemployment benefits, b, plus the expected capital gain associated with becoming matched with a low-tech job, which is realised at an effective rate $\theta q(\theta)\phi$. A skilled worker also enjoys the value of unemployment benefit and the expected capital gains resulting from a match with either of the two job types: with an effective rate of $\theta q(\theta)\phi$, a skilled worker contacts a low-tech vacancy and realises a capital gain $(W_h^n - U_h)$ and with an effective rate $\theta q(\theta)(1-\phi)$ he or she meets a high-tech job and realises $(W_h^s - U_h)$ capital gains. Note that the term $\max[W_h^n - U_h, 0]$ captures the fact that it may not be *worthwhile* for a skilled worker to match with a low-tech vacancy. However, given our interest in cross-skill matching, we have assumed that the parameter values of the model are so that it is optimal for a skilled unemployed worker to accept either of the two job types. (The requirements for the existence of a unique cross-skill matching equilibrium are discussed later in this chapter.)

The corresponding flow value of employment to a worker of type i in a job of type j satisfies the Bellman equation,

$$rW_i^j = w_i^j - \delta\left(W_i^j - B^j - U_i\right), \tag{4}$$

where $\delta > 0$ is an exogenous job destruction rate (Gertler et al., 2008; Hall, 2005)**,** which is assumed to apply to all match relationships.[14] Equation (4) shows that the flow value of employment consists of a worker's wage w_i^j less the expected capital loss associated with job separation. At a rate δ, the worker loses the value W_i^j of being in employment and becomes unemployed with a value U_i. We assume that severance compensation $\left(B^j\right)$ is received by each worker upon match separation, depending on the job types and not the worker's skill. The latter is motivated by the fact that workers on the same job produce an equal amount of output, irrespective of their skill type. Hence, we let $B^s > B^n$ on the grounds that workers employed in high-tech jobs type generate greater output than those employed in low-tech jobs.

From firms' perspective, the value of a filled job of type j with a worker of type i satisfies the Bellman equation,

$$rJ_i^j = y^j - w_i^j - \delta\left(J_i^j - V^j + F^j\right), \tag{5}$$

where F^j denotes a firm's total firing costs per worker, which consists of procedural cost (PC)

[14] Using the data on Danish and Norwegian workers, Bagger and Henningsen (2008) estimate the monthly job hazard function for different education groups and find that workers with lower education level have higher hazard rates during the first few years of work but the difference with the hazard rate of the educated workers closes up after five years of tenure. Thus, it is plausible to assume common job destruction rate in the current model.

and severance compensation (B), i.e. $F^j = PC^j + B^j$.[15] The former is further assumed to consist of two ingredients: (i) a fixed separation cost – including administrative procedures and advance notice period requirements for termination of a job match – which is independent on the job type and (ii), a cost whose amount depends on severance compensation B^j and in our model captures the situation in which a firm's legal expenses is proportional to the amount it ought to pay the worker being fired.[16] Thus, we define $PC^j = \alpha + \eta B^j$, $\alpha > 0$, $0 < \eta < 1$. The flow value a filled job is thus given by the worker's net contribution to the match, $y^j - w_i^j$, where y^j is the output of the job match and w_i^j is the labour cost, and the expected capital loss when the match is destroyed, $\delta(J_i^j - V^j + F^j)$, which is increasing in firing cost F^j.

The respective flow values of low-tech and high-tech vacancies satisfy Bellman equations,

$$rV^n = -(1-\zeta)c + q(\theta)\{\gamma(J_l^n - V^n) + (1-\gamma)\max(J_h^n - V^n, 0)\} \tag{6}$$

and

$$rV^s = -(1-\zeta)c + q(\theta)(1-\gamma)(J_h^s - V^s), \tag{7}$$

where $c > 0$ denote the flow cost of maintaining a vacancy. Equation (6) captures the assumption that a low-tech vacancy can be filled either by a skilled or an unskilled worker. In particular, it must be *worthwhile* for a firm with a low-tech vacancy to match with a skilled worker and this requires that the resulting match surplus must be nonnegative, $J_h^n - V^n \geq 0$. Similarly, equation (7) reflects the fact that only skilled workers can be matched with high-tech jobs, at an effective rate $q(\theta)(1-\gamma)$. The cost, c, of maintaining each vacancy (which can be thought as reflecting the cost of recruiting workers or creating a vacancy, as in the literature) reduces the respective flow values; thus, we assume that each firm receives a subsidy, ζ, per vacancy created.

2.2.3 Wage Determination

As already indicated, the wage rate for each job match is bargained between the worker and the firm through Nash bargaining solution. In particular, Nash bargaining requires that the wage rate for a job match should be such that maximises the weighted product of the firm's and the worker's respective surpluses from the job match, defined by $\left(J_i^j - V^j\right)^{1-\beta}\left(W_i^j - U_i\right)^{\beta}$, subject to (4) and (5). The parameter $0 < \beta < 1$ is a measure of a worker's relative bargaining power

[15] As stressed by, e.g., Bentolila and Bertola (1990) and Garibaldi and Violante (2000), a typical firm's total firing cost consists of procedural costs, advanced notice requirements, legal costs, court penalties and severance transfer. Here we distinguish between two main components: severance transfer and procedural cost, where the latter is assumed to capture other elements of firing costs other than the severance component.

[16] Belgium is an example of a country with unified notice period status. Specifically, effective from January 2014, the Belgian authority introduced a law which requires employers to take into account only the employees' period of service rather than the workers' skills (blue- and white-collar workers). Available at http://www.freshfields.com/uploadedFiles/Locations/Global/EPB_Webinars/PG_EPB_Changes%20in%20Belgian%20Dismissal_V3.pdf.

taken to be exogenously given (Pissarides, 2000). The first order condition with respect to (w.r.t) w_i^j yields

$$(1-\beta)\frac{\partial J_i^j}{\partial w_i^j}\left(W_i^j - U_i\right) = \beta\frac{\partial W_i^j}{\partial w_i^j}\left(J_i^j - V^j\right), \tag{8}$$

which gives rise to the following surplus sharing rule:

$$\left(W_i^j - U_i\right) = \beta S_i^j \tag{9}$$

and

$$\left(J_i^j - V^j\right) = (1-\beta)S_i^j. \tag{10}$$

The above implies that a worker receives share β of the sum of the match surplus, S_i^j, while the remaining share, $(1-\beta)$, goes to the firm. In the symmetric case considered by Pissarides (2000, ch. 1), both the worker and the firm receive an equal share of the match surplus, i.e. $\beta = 1/2$. Setting $V^j = 0$ (free-entry condition, defined later) and substituting the values of employment, W_i^j, and that of a filled job, J_i^j, in equations (4) and (5), into (1), the expression for the surplus of a job match can be obtained as

$$S_i^j = \frac{y^j - \delta\left(\alpha + \eta B^j\right) - rU_i}{r+\delta} \geq 0; j = n, s; \;\; i = l, h. \tag{11}$$

Since $y^s > y^n$ and $rU_h > rU_l$, it follows that $S_h^s > S_l^n > S_h^n$.[17] In a policy-free environment, $\alpha = B^j = \eta = 0$; $j = n, s$, the above equation collapses to the match surplus implied by AV-02, where the only important factor determining the surplus of a job match is the individual worker's flow value of unemployment, rU_i, which must be less that match output, y^j; i.e. $y^j > rU_i$. However, equation (11) shows that the match surplus also crucially depends on the expected costs of firing the worker, with $\partial S_i^j/\partial\alpha < 0$ and $\partial S_i^j/\partial B^j < 0$; the latter, as long as $\eta > 0$. The direct effects of severance compensation on equilibrium match surplus vanishes due to the surplus sharing rule, which resonates with Lazear's (1990) neutrality effect under a flexible wage system. The intuition follows from the fact that under a flexible wage setting a firm is able to transfer the burden of severance compensation to the workers through an appropriate wage cut. To see this, substitute equation (11) into (9) to obtain the wage equation,

$$w_i^j = rU_i + \beta\left\{y^j - \delta\left(\alpha + \eta B^j\right) - rU_i\right\} - \delta B^j. \tag{12}$$

The above equation (12) reveals that each employed worker receives a wage rate that is equal to the flow value of unemployment (or equivalently their reservation value as noted by Pissarides, 2000) plus the share β of the rent created by a job match. Clearly, as implied by equation (12), a firm succeeds in shifting the burden of severance compensation through wage reduction, which is applied over the period $1/\delta$ that a job subsists, as captured by the last term

[17] This suggests, from the argument, that firms would deem it less beneficial to experience mismatch. However, given that it may take time to find an unskilled worker to fill a low-tech vacancy, a firm with such vacancy would prefer to match with a skilled worker rather than leave the vacancy unfilled and incur further vacancy maintenance cost.

on the right-hand-side (Garibaldi & Violante, 2000). However, the additional burden associated with firing a worker is split between the firm and the worker, depending on the value of β, the relative bargaining strength of each worker.

2.2.4 Labour Market Equilibrium

Two main types of equilibria can emerge from this model, depending on the model's parameters. The first is the 'cross-skill matching equilibrium' in which it is beneficial for skilled workers to accept both high-tech jobs and low-tech jobs. The second is the equilibrium with 'ex-post segmentation' where it is optimal for skilled workers to accept only high-tech jobs. In the latter, equilibrium results in a perfect match between jobs' skill requirements and those possessed by workers – analogous to Mortensen and Pissarides (2003). We focus on the first equilibrium with cross-skill matching since it is the configuration that is consistent with skill mismatch and allows for competition for low-tech vacancies between skilled and unskilled workers. The parameter configurations required for the existence of a *unique* equilibrium with cross-skill matching are discussed latr.

The equilibrium with cross-skill matching is a vector of endogenous variables $\{\phi, \gamma, \theta, u\}$ satisfying: (i) two steady state flow conditions and (ii) two free-entry conditions, $V^j = 0$. Note also that, in equilibrium, it must be the case that all matches are mutually beneficial in the sense that the surplus arising from each must be positive: $S_h^s > 0, S_h^n > 0$ and $S_l^n > 0$. We describe these conditions characterising the equilibrium in what follows.

2.2.4.1 Steady State Flow Conditions

The two steady state conditions require that the flow out of unemployment must be equals flow into unemployment for unskilled and skilled workers, and these are respectively given by

$$\theta q(\theta)\phi\gamma u = \delta(p - \gamma u) \tag{13}$$

and

$$\theta q(\theta)(1-\gamma)u = \delta\{1 - p - (1-\gamma)u\}. \tag{14}$$

For unskilled workers, equation (13), the flow out of unemployment is given $\phi\theta q(\theta)\gamma u$, where $\phi\theta q(\theta)$ denotes an unskilled worker's effective rate of contacting a low-tech vacancy and γu is the measure of this category of workers who are unemployed. The corresponding flow back into unemployment is $\delta(p - \gamma u)$, where $p - \gamma u$ is a measure of unskilled workers in employment and δ, as before, is the exogenous rate of job destruction. Similarly, for skilled workers (equation (14)), the flows out of unemployment for is $\theta q(\theta)(1-\gamma)u$, where $(1-\gamma)u$ and $\theta q(\theta)$ represent the measure of skilled workers who are unemployed and their job finding rate, respectively. The corresponding flow back into unemployment for this category of workers is $\delta\{1 - p - (1-\gamma)u\}$, where $1 - p$ is the fraction of skilled workers in the labour force and $(1-\gamma)u$ is the measure the unemployed among them.

Solving the two steady state conditions (13) and (14), we obtain the equilibrium equations for the share of low-tech vacancies, ϕ, and the unemployment rate, u, as

$$\phi = \frac{\theta q(\theta)(1-\gamma)p + \delta(p-\gamma)}{\theta q(\theta)\gamma(1-p)} \tag{15}$$

and

$$u = \frac{\delta(1-p)}{[\theta q(\theta)+\delta](1-\gamma)}. \tag{16}$$

The share of low-tech vacancies, ϕ, and the unemployment rate, u – in equations (15) and (16) – are expressed as functions of θ and γ and the other exogenous parameters p and δ. It is easy to show that $\frac{\partial\phi}{\partial\gamma} < 0$ and, conditional on $\gamma > p$, $\frac{\partial\phi}{\partial\theta} > 0$.[18] By contrast, u is unambiguously increasing in γ and decreasing in θ – as illustrated by equations (A16) and (A17) in Appendix 2.

2.2.4.2 Free-entry Conditions:

Free-entry conditions imply that firms post vacancies until the *profit opportunities for new jobs are exploited, driving rents* from vacancies to zero: $V^n = 0$ and $V^s = 0$. Making use of value equations (6) and (7), these conditions yield

$$(1-\beta)\{\gamma S_l^n + (1-\gamma)S_h^n\} = \frac{(1-\zeta)c}{q(\theta)} \tag{17}$$

and

$$(1-\beta)(1-\gamma)S_h^s = \frac{(1-\zeta)c}{q(\theta)}. \tag{18}$$

Note that equation (17) assumes that it is beneficial for a firm with a low-tech vacancy to match with either a skilled or an unskilled worker, given that we focus on cross skill matching equilibrium. However, rather than use conditions (17) and (18) to fully characterise the equilibrium, we impose the *equal-value* condition $V^n = V^s$ as in AV-02.[19] Thus, subtracting (17) from (18) yields,

$$\gamma S_l^n = (1-\gamma)\{S_h^s - S_h^n\}. \tag{19}$$

In what follows, we derive the expressions for the flow values of unemployment, rU_l and rU_h, in order to characterise equation (19) and the subsequent equations. Using equations (10) and (11), the value equations, (2) and (3), for unskilled and skilled workers can be rewritten as

$$rU_l = \frac{(r+\delta)b + \theta q(\theta)\phi\beta\{y^n - \delta(\alpha+\eta B^n)\}}{r+\delta+\theta q(\theta)\phi\beta} \tag{20}$$

and

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[18] Specifically, $\frac{\partial\phi}{\partial\gamma} = -\frac{p(\theta q(\theta)+\delta)}{(1-p)\theta q(\theta)\gamma^2} < 0$ and $\frac{\partial\phi}{\partial\theta} = \frac{\delta(\gamma-p)(\theta q(\theta))'}{\gamma(1-p)[\theta q(\theta)]^2} > 0$, as long as $\gamma > p$.

[19] In section 2.5 below, we show a case where conditions similar to (17) and (18) can be used for joint determination of the market tightness and share of unemployed unskilled workers in the labours force.

$$rU_h = \frac{(r+\delta)b+\theta q(\theta)\beta\{\phi[y^n-\delta(\alpha+\eta B^n)]+(1-\phi)[y^s-\eta B^s]\}}{r+\delta+\theta q(\theta)\beta}. \tag{21}$$

Equations (20) and (21) imply that the equilibrium flow values of unemployment for skilled and unskilled workers consist of the weighted averages of their non-labour income and expected net contribution to employment. Clearly, both equations show that labour market policies also have implications for unemployment flow values of the two types of workers to the extent that they affect their expected net contributions to employment. In particular, whilst the flow value rU_l is influenced only by the policies directed towards low-tech jobs, rU_h is affected by the policies associated the two job types, given cross-skill matching. In both equations, rU_l and rU_h are decreasing in fixed separation cost, α, because both low- and high-tech jobs are affected. However, while rU_h is decreasing in both B^s and B^n, rU_l is decreasing only in B^n. In general, because these policies affect the availability of vacancies and, consequently, the duration of unemployment spell (given by the inverse of workers' job finding rates), both workers are willing to lower their unemployment value (*reservation wage*) in order to increase their chances of employment.

Using equations (11) and (20), the expression for the equal-value condition (19) can be rewritten as

$$(1-\gamma)\{y^s-\delta\eta(B^s-B^n)-y^n\} = \gamma\frac{(r+\delta)\{y^n-\delta(\alpha+\eta B^n)-b\}}{r+\delta+\theta q(\theta)\phi\beta}. \tag{22}$$

The above represents the third equation characterising the cross-skill matching equilibrium. The final equation can be derived using equation (22) together with the free-entry condition, $V^s=0$, equation (18), after some manipulations, as[20]

$$\frac{(1-\beta)\{y^n-\delta(\alpha+\eta B^n)-b\}}{r+\delta+\theta q(\theta)\beta} = \frac{(1-\zeta)c}{q(\theta)}. \tag{23}$$

For given values of exogenous parameters and policy instruments, equation (23) yields a unique solution for the market tightness, θ, which reflects vacancy creation activities. In fact, equation (23) corresponds to the standard job creation condition in the literature (e.g., Pissarides, 2000; Yashiv, 2007) and shows that the present discounted profit of a filled job must be equal to the average cost of creating a vacancy. Any changes in the average cost of creating a vacancy (the right-hand-side of (23)) relative to the expected gain (the left-hand-side, or vice versa, must be met through a direct policy intervention (e.g. subsidy) or by adjustment in vacancy creation rate to restore the equality condition. The latter occurs through $\theta q(\theta)$ and $q(\theta)$.

2.2.5 Cross-Skill Matching Equilibrium – Summary

For convenience, we repeat the equations which characterise the steady state equilibrium with cross skill matching as follows:

[20] See sub-section 2A.1 in Appendix 2 for the derivation.

$$\phi = \frac{\theta q(\theta)(1-\gamma)p + \delta(p-\gamma)}{\theta q(\theta)\gamma(1-p)}, \tag{15}$$

$$u = \frac{\delta(1-p)}{[\theta q(\theta)+\delta](1-\gamma)}, \tag{16}$$

$$(1-\gamma)\{y^s - \delta\eta(B^s - B^n) - y^n\} = \gamma \frac{(r+\delta)\{y^n - \delta(\alpha+\eta B^n) - b\}}{r+\delta+\theta q(\theta)\phi\beta}, \tag{22}$$

$$\frac{(1-\beta)\{y^n - \delta(\alpha+\eta B^n) - b\}}{r+\delta+\theta q(\theta)\beta} = \frac{(1-\zeta)c}{q(\theta)}. \tag{23}$$

The model is fully characterized by 8 structural parameters: $y^s, y^n, \delta, r, b, p, c$ and β; 5 policy instruments: B^s, B^n, α, η and ζ; and 4 unknowns: θ, γ, ϕ and u, whose solutions are determined by the 4 equations given above. The solution to the equilibrium system is recursive: for given values of exogenous parameters, equation (23) uniquely solves θ. With knowledge of θ, equations (15) and (22) are solved for ϕ and γ. Finally, given θ and γ, u is solved using equation (16).

2.2.6 Existence of Equilibrium with Cross-Skill Matching

Before proceeding to the evaluation of the model, we first discuss the two conditions required for the existence of a cross-skill matching equilibrium. First, as noted by AV-02 (p. 294) and Dolado et al. (2009, p. 210), a key condition for the existence of a cross-skill equilibrium is that the surplus of a job match between a low-tech vacancy and a skilled worker must be nonnegative, which requires that $y^n - rU_h \geq 0$. Without policies, it can be shown that the parameter configuration that satisfies this condition is given by

$$(r+\delta)(y^n - b) \geq \beta\theta q(\theta)(1-\phi)(y^s - y^n). \tag{24}$$

Second, there is a possibility that a corner solution may emerge, i.e. a situation where firms end up posting only one type of vacancy in the equilibrium. In particular, if p, the fraction of unskilled workers in the labour force, is sufficiently *large* and/or the difference in the productivity of the two job types, $y^s - y^n$, is sufficiently *small*, firms may end up posting only low-tech vacancies such that $\phi = 1$. Suppose $\phi = 1$, in a policy-free equilibrium, this implies that

$$rU_h = rU_l = rU = \frac{(r+\delta)b + \theta q(\theta)\beta y^n}{r+\delta+\theta q(\theta)\beta}. \tag{25}$$

The above shows that when firms choose to post only low-tech vacancies, the flow values of unemployment for skilled and unskilled workers will be equal. Thus, the solution for rU_h in (21) reduces to (20), with $\phi = 1$. Accordingly, the value of a filled low-tech job becomes the same regardless of the worker type employed, i.e., $J_l^n = J_h^n$. To rule out the possibility of a corner solution, a sufficient condition is that any *deviant* firm that chooses to post a high-tech vacancy when $\phi = 1$ must make a negative profit. This requires that that $(y^n - rU) > (1-p)(y^s -$

rU). Using equation (25), this condition can be rewritten as[21]

$$y^n - b > (1-p)\left(y^s - b + \frac{\beta\theta^* q(\theta^*)(y^s - y^n)}{r+\delta}\right), \tag{26}$$

where θ^* represents the equilibrium market tightness that solves equation (23).[22] Condition (26) shows that the higher fraction of unskilled workers in the labour force, p, the higher the incentive to post low-tech vacancies. More so, the smaller is $y^s - y^n$, for a given p value, the lower the incentive to post high-tech vacancies. It follows that, in addition to having more skilled workers in the labour force, the output of high-tech jobs must also be reasonably high in order to attract firms to post high-tech vacancies and to avoid equilibrium where firms allocate all vacancies towards low-tech job type.

2.3 Comparative Statics (Qualitative Evaluation)

We now turn to evaluate the qualitative effects of the policy instruments on the endogenous variables. Consider a sudden increase in severance compensation B^n.[23] As equation (23) uniquely determines θ, the initial impact of this is to induce additional match separation cost – the extent of which is determined by η, the measure of EPL strictness. To see this, we differentiate equation (23) w.r.t B^n, considering θ as a function of B^n. This yields, as shown in equation (A7) in Appendix 2,

$$\frac{\partial\theta}{\partial B^n} = -\frac{(1-\beta)\delta\eta\theta q(\theta)}{[\theta q(\theta)\beta + \mu(r+\delta)](1-\zeta)c} < 0.$$

Thus, contrary to the conventional wisdom, as long as $\eta > 0$, the partial effect of B^n on θ is unambiguously negative. The fixed separation, α, also has an unambiguous negative effect on market tightness via the reduction in vacancy creation. The intuition is that as α rises the expected gain from posting vacancies reduces, inducing firms to scale back on vacancy creation in order to stimulate job competition among the unemployed. This, in turn, leads to higher vacancy filling rate (since $q'(\theta) < 0$) and lower the average cost of posting vacancies.

Recruitment subsidy, in contrast, has an opposite effect on job creation. It can be shown that the partial derivative of θ w.r.t ζ also yields, equation (A9) in Appendix 2,

$$sign\left(\frac{\partial\theta}{\partial\zeta}\right) = sign\left(\frac{(1-\beta)\{y^n - \delta(\alpha+\eta B^n) - b\}\theta q(\theta)}{[\theta q(\theta)\beta + \mu(r+\delta)](1-\zeta)^2 c}\right).$$

The above shows that subsidy unambiguously increases market tightness $\left(\frac{\partial\theta}{\partial\zeta} > 0\right)$ as long as the expected profit from a filled job is positive, which requires that $y^n > \delta(\alpha + \eta B^n) +$

[21] See Appendix 2 for the derivation. Note that with policies (24) and (26) become $y^n + \frac{\beta\theta q(\theta)\phi\delta(\alpha+\eta B^n)}{r+\delta} - b \geq \frac{\beta\theta q(\theta)(1-\phi)(y^s - \eta B^s - y^n)}{r+\delta}$ and $y^n - b + \frac{\delta(\alpha+\eta B^n)}{r+\delta} > (1-p)\left(y^s - b + \frac{\beta\theta^* q(\theta^*)[y^s - (y^n - \delta(\alpha+\eta B^n))]}{r+\delta}\right)$, respectively.

[22] Another way to know when a cross-skill equilibrium exist is that $\gamma > p$. This is based on the fact that the fraction of high-tech jobs must be positive, i.e., $(1-\phi) = \frac{(\gamma-p)(\theta q(\theta)+\delta)}{\theta q(\theta)\gamma(1-p)} > 0$.

[23] See Appendix 2 for the details of the comparative statics used in this subsection.

b. Intuitively, a firm must be able to generate a nonnegative profit from a job in order for the subsidy to be effective.

An increase in severance compensation, B^s, on high-tech job has no direct effect on equilibrium job creation condition (23), but alters the allocation of vacancies to each job type. As established in equations (A11) and (A13) in Appendix 2, an increase in B^s unambiguously increases the share of low-tech vacancies, ϕ, and decreases the fraction of unskilled unemployed workers, γ. The intuition is that a higher B^s imposes higher separation costs on firms with high-tech jobs, leading to allocation of vacancies towards low-tech job type. Increase in the share of low-tech vacancies raises the labour market prospect for the unskilled – in terms of higher job finding rate – thus, leading to a lower fraction of unskilled seeking for jobs.

The increases in B^n and α also affect the share of unskilled workers in unemployment, γ, as well as the fraction of low-tech vacancies, ϕ. Holding θ constant so that $d\theta = 0$, it can be shown that an increase in either B^n or α leads to a higher γ and a lower ϕ. Intuitively, because the gains associated with low-tech job drops as either B^n or α rises, the incentive to allocate vacancies towards low-tech job type reduces, and so ϕ drops. Assuming we relax the initial assumption and allow market tightness to reflect the changes in these policy instruments, i.e., $d\theta \neq 0$, then the effects of the two policy instruments (B^n and α) on the share of unemployed unskilled workers, γ, and the fraction of low-tech vacancies, ϕ, become ambiguous. Using the block (15), (22) and (23) we have the following partial effect (see equation (A12) in Appendix 2)

$$sign\left(\frac{\partial\phi}{\partial B^n}\right) = sign\left(\frac{\frac{\partial\phi}{\partial\gamma}[(r+\delta)+(1-\gamma)\theta q(\theta)\phi\beta]\delta\eta \; + \; \frac{\partial\theta}{\partial B^n}\left(\frac{\partial\phi}{\partial\theta}\lambda_2 + \frac{\partial\phi}{\partial\gamma}\lambda_3\right)}{|A|_1}\right),$$

where $|A|_1 = \frac{\lambda_1\left((r+\delta+\theta q(\theta)\phi\beta) \; - \; \frac{\partial\phi}{\partial\gamma}\gamma(1-\gamma)\,\theta q(\theta)\beta\right)}{(1-\gamma)(r+\delta+\theta q(\theta)\phi\beta)}$, $\lambda_2 = \frac{(r+\delta)\{y^n-\delta(\alpha+\eta B^n)-b\}}{(1-\gamma)}$ and $\lambda_3 = (1-\gamma)\{y^s-\delta\eta(B^s-B^n)-y^n\}\big(\theta q(\theta)\big)'\phi\beta$. Note that $\lambda_2 > 0$ and $\lambda_3 > 0$ based on the assumption above and by virtue of (22), respectively. As the denominator of the above is positive, $|A|_1 > 0$, the sign of the above derivation depends on the numerator. However, given that, $\frac{\partial\phi}{\partial\theta} > 0$, $\frac{\partial\theta}{\partial B^n} < 0$ and $\frac{\partial\phi}{\partial\gamma} < 0$, then $\frac{\partial\phi}{\partial B^n}$ is somewhat ambiguous. In the next section, we use numerical solutions to resolve this ambiguity.

The recruitment subsidy has a well-defined positive effect on the share of unemployed unskilled workers, γ, but with an ambiguous effect on the fraction of low-tech vacancies, ϕ. As derived in Appendix 2 (equation (A14)) the partial derivative $\frac{\partial\gamma}{\partial\zeta}$ gives,

$$sign\left(\frac{\partial\gamma}{\partial\zeta}\right) = sign\left(\frac{\frac{\partial\theta}{\partial\zeta}\left[\big(\theta q(\theta)\big)'\phi\beta \; + \; \frac{\partial\phi}{\partial\theta}\theta q(\theta)\beta\right]\gamma\lambda_1}{|A|_1(r+\delta+\theta q(\theta)\phi\beta)}\right),$$

where $\lambda_1 = (r+\delta)\{y^n - \delta(\alpha+\eta B^n) - b\}$. Thus, provided $\lambda_1 > 0$, which is conditional on $y^n > \delta(\alpha+\eta B^n) + b$ as above (also see Burda, 1990), and $|A|_1 > 0$, we have $\frac{\partial\gamma}{\partial\zeta} > 0$, since as $\frac{\partial\theta}{\partial\zeta} > 0$ and $\frac{\partial\phi}{\partial\theta} > 0$, conditional on $\gamma > p$ as in AV-02 and Blázquez and Jansen (2008). Below we examine how specific unemployment rates react to policy instruments.

To demonstrate the impacts of the above policy instruments on unemployment rate we resort to equation (16), which implies $u = u[\theta(B^n,\zeta,\alpha,X_i),\gamma(B^n,B^s,\zeta,\alpha,X_i)]$, where θ and γ are two intermediate variables directly determining u, but dependent on policy instruments as well as other exogenous parameters, denoted by X_i. Thus, we evaluate each policy instrument at a time, setting all variations in $X_i = 0$ and noting that $\frac{\partial u}{\partial\gamma} > 0$ and $\frac{\partial u}{\partial\theta} < 0$. Suppose there is an increase in the separation cost induced by a change in B^s. As B^s has no direct effect on the market tightness, θ, vacancy creation rate remains unaffected in equilibrium, all else equal. However, as we have already established, an increase in B^s raises the availability of low-tech vacancies, ϕ, and reduces the share of unskilled workers, γ. Thus, we expect a decrease unemployment rate, given that $\frac{\partial u}{\partial\gamma} > 0$. The effects of B^n and α are somewhat ambiguous: a rise in either B^n or α reduces θ, but with ambiguous effects on γ. Therefore, their overall impact on unemployment is qualitatively unclear.

Next, we evaluate the effect of policy instruments on the specific unemployment rate for each worker type. Using equation (13), as in Dolado et al. (2009), we can define the unemployment rate of unskilled workers as the ratio of unskilled unemployed workers, measured by γu, to the share of unskilled workers in the labour force, p; i.e., $u_l \equiv \frac{\gamma u}{p} = \frac{\delta}{[\theta q(\theta)\phi+\delta]}$. Similarly, from equation (14) the unemployment rate of skilled workers can be defined as $u_h \equiv \frac{(1-\gamma)u}{1-p} = \frac{\delta}{[\theta q(\theta)+\delta]}$, where $(1-\gamma)u$ is a measure of skilled unemployed workers and $1-p$ is the share of skilled workers in the labour force. It is immediate to see that $\frac{\partial u_l}{\partial\theta} < 0$, $\frac{\partial u_l}{\partial\phi} < 0$ and $\frac{\partial u_h}{\partial\theta} < 0$. It follows that changes in B^n and α both have ambiguous effects on u_l due to the ambiguous impacts of both policies on the share of low-tech vacancies, ϕ. However, for the workers who are skilled, the rise in B^n and α unambiguously increase their unemployment rate, u_h, since it is driven mainly by market tightness, θ.

An increase in subsidy unambiguously leads to a decrease in the skilled workers' unemployment rate, since $\frac{\partial\theta}{\partial\zeta} > 0$. However, the effects of subsidy on the aggregate and unskilled workers' unemployment rates, u and u_l, are somewhat ambiguous, qualitatively. In particular, in Appendix 2, we show that the partial effect of subsidy on aggregate unemployment rate yields, equation (A20),

$$sign\left(\frac{\partial u}{\partial\zeta}\right) = sign\left(\frac{\delta(1-p)}{(\theta q(\theta)+\delta)(1-\gamma)^2}\frac{\partial\gamma}{\partial\zeta} - \frac{\delta(1-p)\big(\theta q(\theta)\big)'}{[\theta q(\theta)+\delta]^2(1-\gamma)}\frac{\partial\theta}{\partial\zeta}\right).$$

As has already been established, by reducing the cost of vacancy creation, an increase in subsidy raises market tightness, $\frac{\partial\theta}{\partial\zeta} > 0$. Therefore, the exit rate unemployment is expected to be higher, due to the tightening in the labour market. Whether or not subsidy ultimately reduces u, however, depends on the response of the share of unskilled workers, γ; but as we have shown, $\frac{\partial\gamma}{\partial\zeta} > 0$ and $\frac{\partial u}{\partial\gamma} > 0$. It follows that for an increase in subsidy to reduce the aggregate unemployment rate, its effect through market tightness, i.e., $\frac{\partial\theta}{\partial\zeta} > 0$, must be sufficiently large so as to make $\frac{\partial u}{\partial\zeta} < 0$.

2.4 Numerical Evaluation

Here we use numerical examples to gauge the quantitative importance of policy instruments as well as clarify any ambiguity noted in the preceding section. We first discuss the calibration strategy and then the results from our simulation exercises.

2.4.1 Model Calibration

We calibrate the model such that the initial solution for the fraction of low-tech vacancies, ϕ, is at least 70 percent to reflect the percentage of small and medium-sized enterprises in the OECD countries which ranges from 69 percent in Ireland to 96.5 in Greece (OECD, 2013b). Also, aggregate unemployment is targeted at around 8 percent to capture the OECD average in recent years. In doing these, we take into consideration that our parameterisations should be such that they guarantee the existence of a cross-skill matching equilibrium outlined previously.

To commence the calibration, we need to specify the functional form for the matching technology. As in Hagedorn, Manovskii, and Stetsenko (2016) we assume that the matching technology takes the Cobb-Douglas form given by $m(u, v) = \chi u^{\mu} v^{1-\mu}$, where $\chi > 0$ is a positive constant reflecting the efficiency of matching technology and μ captures matching elasticity, assumed to be between 0 and 1 (Krause & Lubik, 2010; Ravenna & Walsh, 2012). This functional form thus allows us to rewrite a firm's vacancy filling rate as $\frac{m(u,v)}{v} \equiv q(\theta) = \chi\theta^{-\mu}$ and the corresponding worker's job finding rate as $\frac{v}{u}\frac{m(u,v)}{v} \equiv \theta q(\theta) = \chi\theta^{1-\mu}$. The summary of the baseline calibration is provided in Table 2.2 in Appendix 2.

The bargaining power of workers is conventionally assumed to be symmetric, as in Pissarides (2000). Therefore, we let $\beta = 1/2$, which implies that the agents to a job match to have an equal share of the match surplus. Following Dolado et al. (2009) and many other studies in search literature, we set matching elasticity μ to equal β. This ensures that the share of the match surplus received by each party to a job match equals their contribution to matching; thus, satisfying the Hosios (1990) condition.[24] The value of unemployment benefit is set as $b = 0.1$

[24] See Hosios (1990) and Pissarides (2000, ch. 8) for details.

as in Dolado et al. (2009) and falls between the 0.1, chosen by AV-02, and 0.349, set by Mortensen and Pissarides (2003). Other parameters: the interest rate $r = 0.05$, job separation rate $\delta = 0.2$, the fraction of unskilled workers in the labour force $p = 2/3$, the measure of match efficiency, $\chi = 2$ and the cost of posting each vacancy $c = 0.5$ are chosen in line with AV-02 and Dolado et al. (2009). We normalize the output of low-tech job type $y^n = 1$ and set that of high-tech job as $y^s = 1.4$, close to the value chosen by Dolado et al. (2009). Finally, we assume a policy-free initial equilibrium and, thus, set $\alpha = B^j = \eta = \zeta = 0;\ j = n, s$.

2.4.2 Numerical Results

The second row (Bench) of Table 2.3 in Appendix 2 summarises the benchmark steady state solution of the model. The initial solution to model shows that the duration of unemployment for skilled and unskilled workers differ quite considerably. With a job finding rate of $\theta q(\theta) = 2.4449$, a skilled worker spends approximately 4.9 months in unemployment on average, whereas the unskilled counterpart spends 5.7 months searching for job which he finds with an effective rate of $\phi\theta q(\theta) = 2.0941$. For skilled and unskilled workers, the steady state solution yields an average unemployment rate of 7.56 and 8.72 percent respectively. Aggregate unemployment (u) is approximately 8 percent, while the fraction of low-tech vacancies is approximately 85.7 percent, within the range outlined above.

We focus on examining the effects of changes in specific instruments on endogenous variables. Note that in isolation, severance compensation $(B^j; j = n, s)$ and the measure of EPL strictness (η) have no 'real' effect on labour market outcomes. This is because the direct effect of severance compensation disappears through wage negotiation as noted previously. The cost induced by severance, however, can be examined if there is some form of strictness in the EPL, $(\eta > 0)$. Thus, we set the measure of EPL strictness, η, to 0.5 to enable us examine the effects of severance induced cost on the variables. Table 2.3 in Appendix 2 shows the effects of changes in individual policy instruments $(\alpha, \zeta, B^n$ and $B^s)$ on the labour market.

Fixed separation cost and low-tech severance compensation: As can be seen, an increase in α and B^n have similar qualitative effects on labour market outcomes; quantitatively, however, these effects differ. In both cases job creation reduces, causing market tightness, θ, to fall. A lower θ, in turn, reduces job finding rate, leading to higher unemployment rate across all categories of worker. The unskilled workers are worse off by the increases in α and B^n, both in terms of percentage decrease in job finding and increase in unemployment rates. In fact, our result reveals that in all cases with changes in B^n, the percentage increase in the unemployment rate of the unskilled is at least three times the increase in that of skilled workers. However, in the case of α, while the unskilled are also worse off, the impact is less compared to B^n. These results are broadly supported by Boeri et al. (2012) who stressed that the unemployment rate of unskilled workers tends to be more responsive to changes in EPL than that of skilled worker. The intuition, based on our model, is that as α and B^n increase, low-tech job matches become less attractive, inducing firms to shift the allocation of vacancies towards high-tech job type; thus, creating a much more favourable market prospect for skilled workers. However, given that both α and B^n have negative impacts on the overall job creation, as reflected in the decrease in θ, u_h rises but not as much as the increase in u_l. In general, there is an increase in the aggregate unemployment as shown by the rise in u, due to deterioration in labour market condition.

High-tech severance compensation: In contrast to α and B^n, an increase in severance compensation B^s on high-tech jobs reduces the aggregate unemployment rate, u. The reason is that a higher B^s lowers the profitability of high-tech jobs, shifting vacancy allocation in favour of low-tech job type. As θ is independent of B^s (by virtue of equation (23)), it remains unaffected. Thus, the effect of B^s is essentially to influence vacancy allocation. Quantitatively, as shown in Table 2.3, the share of low-tech vacancies, ϕ, rises by 2 and 8 percent when B^s rises by 0.1 and 0.5 percentage points respectively. The increase in the availability of low-tech vacancies raises the effective job finding rate of unskilled workers, leading to decrease in the share of the unskilled unemployed, γ. Consequently, the unemployment rate of this category of workers, u_l, falls, while that of skilled workers remains the same as B^s rises. Intuitively, given that skilled workers can undertake any of the two job types, even though the share of high-tech vacancies drops, the increased availability of low-tech vacancies induces some skilled workers to match with low-tech jobs rather than remain unemployed.

Recruitment subsidy**:** Compared to other instruments, a rise in recruitment subsidy ζ boosts vacancy creation and lowers unemployment across skills. The immediate impact of subsidy is to reduce vacancy creation cost, thereby raising market tightness, θ. Given that productivities of the two job types are unaffected by ζ, there is tendency for firms to shift allocation of these vacancies in towards high-tech jobs since they have higher productivity, all else equal. Consequently, ϕ falls. However, the improvement in the job finding rate, resulting from the increase in market tightness, for both types of workers leads to a reduction in unemployment rate across board. The reason that unskilled workers' unemployment rate, u_l, falls, even though ϕ declines, is that crowding out effect reduces given the increase in vacancy creation activities. Intuitively, as more high-tech vacancies become available, the arrival rate of such vacancies to skilled workers increases; thus, leading to a reduction in the competition for low-tech vacancies.

2.5 Fixed Wage Model with Labour Market Policies

In the previous section, we showed that the direct effect of severance compensation on labour market outcomes can be neutralised via Nash bargaining process, as reflected in the wage equation (12), but not the additional cost it creates. However, with a rigid wage structure, firms are typically unable to transfer (or share) the cost imposed by severance compensation to the workers through wage cut (Garibaldi & Violante, 2000). This implies that severance cost itself can have a *real* effect on firms' vacancy creation and allocation decisions, which, in turn, influences unemployment rate and other labour market outcomes. Here, we assume that wages are predetermined (exogenously determined) – similar to Cahuc and Barbanchon (2010, p. 198). Additionally, we maintain the assumption that a skilled worker that is matched with a low-tech vacancy earns a wage rate greater that than that of an unskilled worker on the same job; i.e., $w_l^n < w_h^n < w_h^s$. The new equilibrium with cross skill matching and fixed wage can be summarised as follows,

$$\phi = \frac{\theta q(\theta)(1-\gamma)p + \delta(p-\gamma)}{\theta q(\theta)\gamma(1-p)}, \tag{15}$$

$$u = \frac{\delta(1-p)}{[\theta q(\theta) + \delta](1-\gamma)}, \tag{16}$$

$$u_l \equiv \frac{\gamma u}{p} = \frac{\delta}{\theta q(\theta)\phi + \delta}, \tag{27}$$

$$u_h \equiv \frac{(1-\gamma)u}{1-p} = \frac{\delta}{\theta q(\theta) + \delta}, \tag{28}$$

$$y^n - [\gamma w_l^n + (1-\gamma)w_h^n] - \delta F^n - \frac{(r+\delta)(1-\zeta)c}{q(\theta)} = 0, \tag{29}$$

$$(1-\gamma)[y^s - w_h^s - \delta F^s] - \frac{(r+\delta)(1-\zeta)c}{q(\theta)} = 0, \tag{30}$$

where equations (27) and (28) characterise the unemployment rate of unskilled and skilled workers defined previously in section 2.3. Equations (29) and (30) now respectively represent vacancy creation conditions for low- and high-tech vacancies, obtained by imposing free-entry requirements, $V^n = 0$ and $V^s = 0$, equations (6) and (7), and using (5). Note that we have taken into consideration that firms with low-tech vacancies can employ any type of worker, whereas those with high-tech vacancies can only hire skilled workers. Due to free-entry condition, the expected profit must be equal to the average cost of creating the vacancy, the equivalence of equations (17) and (18). Notice that compared to the flexible wage structure in the previous section, a firm now entirely bears the burden of the total firing cost $F^j = \alpha + (1+\eta)B^j;\ j = n, s$, which includes the value of severance payment and the additional cost it induces.

2.5.1 Comparative Statics under Fixed Wage

In the new setting, equations (29) and (30) jointly determine the equilibrium θ and γ. More formally, let the values of having low- and high-tech job to the firms, i.e., (29) and (30), be denoted by $V^n(\theta,\gamma)$ and $V^s(\theta,\gamma)$ respectively. It can be shown that $\left.\frac{\partial V^n(\theta,\gamma)}{\partial\theta}\right|_\gamma < 0$, $\left.\frac{\partial V^n(\theta,\gamma)}{\partial\gamma}\right|_\theta > 0$, $\left.\frac{\partial V^s(\theta,\gamma)}{\partial\theta}\right|_\gamma < 0$ and $\left.\frac{\partial V^s(\theta,\gamma)}{\partial\gamma}\right|_\theta < 0$, noting that $q'(\theta) < 0$. The intuition behind these results is straightforward. The lower is the value of θ the easier it is for firms to fill both low-tech and high-tech vacancies. The reason is that fewer vacancies lead to an increase in the competition for jobs, driving down the duration of vacancies $(1/q(\theta))$ and, consequently, the average vacancy creation cost. Therefore, the value of each job type to the firm increases, for a given fraction of unskilled unemployed workers, γ. More so, for a given value of market tightness, θ, a higher γ implies higher expected profit for firms with low-tech vacancies. Intuitively, because low-tech job type pays lower wage rate to unskilled workers, its value $\left(V^n(\theta,\gamma)\right)$ increases with γ. A similar explanation applies high-tech jobs which become less attractive as the share of unskilled unemployed workers, γ, rises, for a given θ value. Given the relationships stated above, $V^n(\theta,\gamma)$ and $V^s(\theta,\gamma)$ can be depicted diagrammatically in a $\theta-\gamma$ space, as shown in Figure 2.1 in Appendix 2, where the former is upward-sloping and latter is downward-sloping.[25]

The point of intersection of the two curves determines the unique equilibrium values of θ and γ. Inspecting the figure, it is easy to qualitatively compare how changes in policy instruments influence the equilibrium variables θ and γ. A rise in severance compensation B^n raises the total firing cost F^n and shifts $V^n(\theta,\gamma)$ curve to the left, while $V^s(\theta,\gamma)$ curve remains unaffected. In other words, whilst the equilibrium market tightness θ falls, the fraction γ of unskilled unemployed workers rises. Intuitively, given that B^n affects only low-tech jobs, as θ falls, the share of low-tech vacancies reduces, leading to an increase in the fraction of unskilled unemployed workers, γ. By contrast, an increase in B^s raises F^s and shifts $V^s(\theta,\gamma)$ curve down, leaving $V^n(\theta,\gamma)$ curve unchanged. As a consequence, the equilibrium θ decreases because firms cut back on the creation of high-tech vacancies. By differentiating $V^s(\theta,\gamma)$ w.r.t. B^s, considering B^s as a function of γ and holding θ constant, we find that γ also falls.

The effects of the fixed separation cost, α, on the market tightness and the share of the unskilled unemployed are qualitatively the same as the effects of severance payments, B^n. However, unlike B^n, α affects both F^n and F^s. Specifically, an increase in α raises both F^s and F^n, and shifts $V^s(\theta,\gamma)$ downwards and $V^n(\theta,\gamma)$ to the left. The reason is that – irrespective of the type – the expected profit of filled jobs falls. This, in turn, leads to a reduction in vacancy creation and therefore market tightness, θ. Since α shifts $V^s(\theta,\gamma)$ downward and $V^n(\theta,\gamma)$ to the left, its effect of on γ is somewhat ambiguous from the diagram. We can however straightforwardly establish this effect by differentiating (29) and (30) w.r.t α, assuming that γ is a function of α and holding θ fixed. The result shows that the increase in α also increases the fraction of unskilled workers in unemployment, γ. So we would expect a larger shift in $V^n(\theta,\gamma)$ curve to the left than the downward shift in $V^s(\theta,\gamma)$ curve. This suggests that the negative effects of α through $V^n(\theta,\gamma)$ dominates; i.e., the increase in α is more harmful to firms with low-tech vacancies than it is to firms with high-tech vacancies. The reason for this follows from our previous explanation: given that α is common to the two job type, posting high-tech vacancies is generally more attractive since, ceteris paribus, they attracts higher profits to firms compared to low-tech vacancies. Hence, the fraction of low-tech vacancies reduces by more,

[25] Implicit differentiation of $V^n(\theta,\gamma)$ and $V^s(\theta,\gamma)$ yield $\frac{\partial\gamma}{\partial\theta}=-\left(\frac{(r+\delta)(1-\zeta)q'(\theta)}{w_h^n-w_l^n}\right)>0$ and $\frac{\partial\gamma}{\partial\theta}=\left(\frac{(1-\gamma)q'(\theta)}{q(\theta)}\right)<0$ respectively, as long as $q'(\theta)<0$ and $w_h^n>w_l^n$ hold.

which then leads to an increase in the fraction of the unskilled in unemployment.

An increase in recruitment subsidy ζ shifts $V^s(\theta,\gamma)$ up and $V^n(\theta,\gamma)$ to the right, so it unambiguously raises θ. Again, the diagram presents an ambiguous picture of the effect of ζ on the share γ of unskilled workers in unemployment. Using equations (29) and (30) and differentiating them individually w.r.t ζ – considering θ and γ as functions of ζ – it is easy to show that the increase in ζ unambiguously raises θ and reduces γ in equation (29), whereas it increases both (θ and γ) in equation (30). These results are very intuitive: it suggests that subsidy could be more effective in reducing the share of unskilled workers in unemployment when availed directly to the firms with low-tech vacancies, than to the firms with high-tech vacancies. Combining the two results, since both equations jointly determine the equilibrium values of θ and γ, we find that the effect of ζ on γ cancels out, whereas the effect on θ remains positive. (Below, we use numerical example to verify this result.)

In order to evaluate the partial effects of the policy instruments on unemployment rate in equation (16) we apply chain rule which takes the form

$$sign\left(\frac{\partial u}{\partial X_\tau}\right) = sign\left(\frac{\partial u}{\partial \theta}\frac{\partial \theta}{\partial X_\tau} + \frac{\partial u}{\partial \gamma}\frac{\partial \gamma}{\partial X_\tau}\right),$$

where X_τ represents the policy instruments, $\tau = B^s, B^n,\ \zeta$ and α whose partial effects are individually examined, keeping the variations in other structural parameters constant. Recall from equation (16) that $\partial u/\partial\theta < 0$ and $\partial u/\partial\gamma > 0$, also see Appendix 2. In other words, the interpretation of the sign of the partial effects of policy instruments on aggregate unemployment rate depends on their initial impact on θ and γ, the two intermediate variables. Since both B^s and B^n reduce aggregate vacancy posting and so the market tightness θ, the exit rate out of unemployment drops. Thus, we would expect a ceteris paribus increase in unemployment rate. However, the effects of B^s and B^n, through γ, on u differ: a rise $B^n(B^s)$ increases (reduces) γ. Given the relation in the equation above, the overall impact of B^n on u is, therefore, positive whereas the effect of B^s is ambiguous. It follows that B^s can only lead to a higher unemployment only if its impact through θ is sufficiently large to dominate its impact through γ, so as to make $\frac{\partial u}{\partial X_\tau} > 0$.

An increase in the fixed cost of separation, as implied by a rise in α, unambiguously reduces θ and increases γ, and so, unemployment rate is higher as α rises. By contrast, an increase in subsidy ζ reduces the cost of job creation and increases the market tightness θ in turn. So we expect aggregate unemployment rate to be lower – for a given γ. The final effect of ζ on u however depends on its effects on the share of unskilled workers that are unemployed, γ. But since the effects of ζ on γ in equations (29) and (30) both cancel out each other, subsidy reduces unemployment mainly by increasing vacancy creation as reflected in a higher the market tightness, θ.

2.5.2 Numerical Examples under Fixed Wage

In this subsection, we use numerical examples to illustrate the implications of changes in policy instruments under flexible and fixed wage system. To do this, we retain the original calibration in the previous sub-section. Also, given that wages are now exogenously determined, we use the initial solution derived under flexible wage model for w_l^n, w_h^n and w_h^s, reported in Table 2.3. Table 2.4 in Appendix 2 shows the benchmark results and comparative statics of the current exercise. We compare instances where α, B^n, B^s and ζ are raised individually by 0.1 percentage point under flexible and fixed wage model.

As the results suggest, firms become extremely sensitive to policies under fixed wage system compared to the flexible wage system; even a small increase in policy instruments produces a large change in the labour market. Given a policy shock an equal magnitude, market tightness drops by more in the cases of α, B^n and B^s under fixed wage, signalling the fact that wages are unable to adjust to absorb part of the cost imposed by these instruments. The unskilled workers are worse off the higher are α and B^n, as before. This is because, by raising the cost of labour to the firms, these policy instruments make vacancy creation unattractive. For a higher B^n, there is a significant shift from low- towards high-tech vacancies, leading to a sharp increase in the unemployment rate of the unskilled.

A higher B^s, however, has an opposite effect, producing a significant rise in the allocation of vacancies towards low-tech job type, as shown by $\phi = 0.9967$. A higher ϕ in turn leads to a considerable rise in the effective job finding rate for the unskilled, resulting in a lower u_l. In fact, the effect of B^s is similar to that produced in AV-02, where $\phi = 1$ as a result of an increase in the fraction of the unskilled in the workforce, p. Similar to the case of p, the reason is that, as B^s rises, the incentive to post low-tech vacancies rises, pushing the equilibrium towards a corner solution where high-tech vacancies disappear. Finally, as we expected, the effect of recruitment subsidy on γ cancels out, as illustrated previously. However, given that vacancy creation rise in general, as shown by the increase in θ, unemployment rate falls across board.

2.6 Robustness Check

To check the robustness of our results, we vary the values of two key parameters emphasised by AV-02 and Dolado et al. (2009), namely, the productivity of high-tech and low-tech jobs, y^s and y^n, respectively. An increase in y^s leaves θ unchanged $\left(\frac{\partial\theta}{\partial y^s} = 0\right)$, by virtue of equation (23). However, given that the productivity gap between low- and high-tech job becomes larger as y^s increases, it leads to a decrease in ϕ, leaving unskilled workers worse off: both u_l and u rise as a result. A higher y^n, in contrast, directly raises job creation, as captured by the increase in θ $\left(\frac{\partial\theta}{\partial y^n} > 0\right)$. Additionally, given that the productivity gap between high- and low-tech jobs reduces as y^n increases, for a given y^s, there is higher incentive to post low-tech vacancies, and so ϕ rises. The increase in ϕ then reduces both u_l and u_h, and consequently u.

Table 2.5 in Appendix 2 summarises our policy experiments for different values of y^s and y^n. We report the responses of variables in terms of percentage change from their benchmark solution. Clearly, the results show that in all scenarios, the qualitative implications of policies remain the same as discussed in the previous section. Quantitatively, however, the magnitude of the impact of these policy instruments, to some extent, depend on the values of y^s and y^n, our main focus parameters. A closer examination shows that an increase in severance compensation on a high-tech job (B^s) tends to lead to a much larger reduction in unemployment rate u the lower is y^s and the higher is y^n. Intuitively, because a lower y^s or a higher y^n, in isolation, implies a reduced productivity gap between low-tech and high-tech job, firms find it more beneficial to shift vacancy allocation towards low-tech job type. The percentage increase in ϕ is, therefore, higher. Thus, given that majority of the workforce are unskilled, i.e., $p = 2/3$, there tends to be much lower aggregate unemployment as the share of low-tech vacancies increases. A similar analogy applies to rise in low-tech severance compensation (B^n), but with opposite effect on u. Fixed separation cost, α, given that it is common to both job type, tends to produce a much larger adverse effect on the aggregate unemployment rate the lower is y^n and the higher is y^s. This is because, with a further decrease y^n, the incentive to allocate vacancies away from low-tech type rises, due to lower payoffs associated with a lower y^n, whereas the payoff on high-tech job rises as y^s increases. For the recruitment subsidy, the percentage decrease in the aggregate unemployment rate is much higher as y^s reduces and as y^n increases. At the same time, there is a greater decrease in the fraction of available low-tech jobs in favour of the high-tech ones. This intuitively implies that as high-tech vacancies become more available, skilled workers become more likely to match with such vacancies. Thus, job competition between the skilled and the unskilled workers reduce, creating higher opportunities for the unskilled workers to match with low-tech vacancies in the market. In general, the qualitative effects of these policies as shown Table 2.5 confirms the robustness of our result, provided the changes in the parameters are within reasonable bounds which ensure the requirements for cross-skill matching hold.

2.7 Conclusion

This chapter has examined the implications of labour market policies on vacancy creation and allocation decisions of firms and unemployment rates in the presence of cross-skill matching. We extended the Albrecht and Vroman (2002) search and matching framework with heterogeneous skilled and unskilled workers and with high-and low-tech jobs. While skilled workers are able to undertake both job types, the unskilled can only undertake on low-tech job type. This gives the former a better market prospect compared to the latter. Within this framework, we considered the effects of specific policies that consist of targeted severance compensation (a less-studies policy instrument) and common fixed firing cost and vacancy creation or recruitement subsidy.

Against conventional wisdom, we show that, as long as there is some degree of enforcement, severance compensation has a non-neutral effect on labour market outcomes. In particular, when directed towards low-tech jobs it leads to a reduction in vacancy creation and a decrease in the proportion of vacancies allocated to low-tech job type. Thus, unemployment rate rises across all categories of workers, but the unskilled are worse-off. By contrast, when targeted on high-tech jobs, severance compensation has an opposite effect on labour market outcomes. Fixed separation cost (common to low- and high-tech jobs) also adversely affects vacancy creation activities, but compared to low-tech job targeted severance, its effects are less. Recruitment subsidy is found to be an effective way of reducing the unemployment rates of skilled and unskilled workers by improving the vacancy creation rate. Such subsidy acts on the market by reducing vacancy creation cost, which, in turn, reduces crowding out effects of unskilled workers by their skilled counterpart. Finally, for comparison, we abstracted from flexible wage setting in which firms can transfer the burden of severance compensation by forcing workers to accept lower wage rate and considered a fixed wage system in which the opposite holds. We find that in the latter, firms become more sensitive to labour policies; even a small change in policy instrument triggers large changes in labour market variables.

Appendix 2

2A Mathematical Derivations and Comparative Statics

2A.1 Equal-value and Job Creation Conditions

Subtract equation (17) from (18) to obtain the equal value condition,

$$\gamma S_l^n = (1-\gamma)(S_h^s - S_h^n), \tag{A1}$$

which is the equation (19) in the text. Next, using equations (11) and (20), equation (A1) can be rewritten as

$$(1-\gamma)\{y^s - \delta\eta(B^s - B^n) - y^n\} = \gamma \frac{(r+\delta)\{y^n - \delta(\alpha+\eta B^n) - b\}}{r+\delta+\theta q(\theta)\phi\beta}, \tag{A2}$$

which characterises the equal value condition, equation (22). To obtain equation (23) in the text, multiply both sides of (A2) by $r+\delta+\phi\theta q(\theta)\beta$ and then add $(1-\gamma)(r+\delta)[y^n - \delta(\alpha + \eta B^n) - b]$ to both sides of the equation. These yields,

$$\theta q(\theta)\beta\{y^s - \delta\eta(B^s - B^n) - y^n + \delta(F^n - B^n)\}$$
$$+(r+\delta)\{y^s - \delta\eta(B^s - B^n) - b\} = \frac{(r+\delta)\{y^n - \delta(\alpha+\eta B^n) - b\}}{(1-\gamma)}. \tag{A3.1}$$

Furthermore, substitute (21) into (18), noting that $V^s = 0$, gives,

$$\theta q(\theta)\beta\{y^s - \delta\eta(B^s - B^n) - y^n + \delta(F^n - B^n)\}$$
$$+(r+\delta)\{y^s - \delta\eta(B^s - B^n) - b\} = \frac{(r+\delta)[r+\delta+\theta q(\theta)\beta](1-\zeta)c}{(1-\gamma)(1-\beta)q(\theta)}. \tag{A3.2}$$

Using both (A3.1) and (A3.2), we obtain the equation (23) in the text,

$$\frac{(1-\beta)\{y^n - \delta(\alpha+\eta B^n) - b\}}{r+\delta+\theta q(\theta)\beta} = \frac{(1-\zeta)c}{q(\theta)}. \tag{A4}$$

This equation produces a unique solution for the market tightness, θ.

2A.2 Cross-skill Matching Equilibrium and Corner Solution

A corner solution exists in equilibrium if firms choose to offer only low-tech vacancies, such that ϕ = 1. In a policy-free environment, this implies that the flow value of vacancies yields,

$$rV^n = -c + q(\theta)(1-\beta)\frac{(y^n - rU)}{r+\delta} = 0, \tag{A5}$$

where rU represents the common flow value of unemployment for the two worker types derived in equation (25), which is now equal since $J_l^n = J_h^n$. To rule out an equilibrium with corner solution, we assume that a *deviant* must make a negative profit for posting a high-tech vacancy when $\phi = 1$. Suppose a firm posts a high-tech job, when $\phi = 1$, the value of the vacancy must satisfy,

$$rV^s = -c + (1-p)q(\theta^*)(1-\beta)\frac{(y^s - rU)}{r+\delta} < 0, \tag{A6}$$

where the market tightness that solves (23) is denoted by θ^*. Comparing both (A5) and (A6), we obtain

$$(y^n - rU) > (1-p)(y^s - rU),$$

which gives the condition that ensures the creation of high-tech job results in a negative profit when ϕ =1. To arrive at equation (26), substitute equation (25) to eliminate rU.

2A.3 Comparative Statics

Since unemployment rate, equation (16), can be solved for given values of model parameters and endogenous variables, we first examine how policies affect ϕ, γ and θ. For the first purpose, we make use of equations (15), (22) and (23), respectively, which we reproduce here for convenience,

$$\phi = \frac{\theta q(\theta)(1-\gamma)p + \delta(p-\gamma)}{\theta q(\theta)\gamma(1-p)}.$$

$$(1-\gamma)\{y^s - \delta\eta(B^s - B^n) - y^n\} = \gamma \frac{(r+\delta)\{y^n - \delta(\alpha + \eta B^n) - b\}}{r + \delta + \theta q(\theta)\phi\beta},$$

$$\frac{(1-\beta)\{y^n - \delta(\alpha + \eta B^n) - b\}}{r + \delta + \theta q(\theta)\beta} = \frac{(1-\zeta)c}{q(\theta)},$$

where ϕ, γ and θ are the three endogenous variables of interest, which are determined by the above equations, and B^n, B^s, ζ and α are policy parameters. To carry out comparative statics, we totally differentiate (15), (22) and (23), setting all structural parameters (including η) variations to zero. For simplicity the results, after some manipulations, are arranged more compactly in a matrix form $A\begin{bmatrix} d\phi \\ d\gamma \\ d\theta \end{bmatrix} = $ g, where

$$A = \begin{bmatrix} 1 & \frac{p(\theta q(\theta)+\delta)}{(1-p)\theta q(\theta)\gamma^2} & -\frac{\delta(\gamma-p)\big(\theta q(\theta)\big)'}{\gamma(1-p)[\theta q(\theta)]^2} \\ (1-\gamma)\{y^s-\delta\eta(B^s-B^n)-y^n\}\,\theta q(\theta)\beta & -\frac{(r+\delta)\{y^n-\delta(\alpha+\eta B^n)-b\}}{(1-\gamma)} & (1-\gamma)\{y^s-\delta\eta(B^s-B^n)-y^n\}\big(\theta q(\theta)\big)'\phi\beta \\ 0 & 0 & \left(\frac{\theta q(\theta)\beta+(r+\delta)\mu}{\theta q(\theta)}\right) \end{bmatrix}$$

and

$$\mathrm{g} = \begin{bmatrix} 0 & 0 & 0 & 0 \\ -[(r+\delta)+(1-\gamma)\theta q(\theta)\phi\beta]\delta\eta & (1-\gamma)\delta\eta(r+\delta+\theta q(\theta)\phi\beta) & 0 & -(r+\delta)\gamma\delta \\ -\frac{(1-\beta)\delta\eta}{(1-\zeta)c} & 0 & \frac{(1-\beta)\{y^n-\delta(\alpha+\eta B^n)-b\}}{(1-\zeta)^2 c} & -\frac{(1-\beta)\delta}{(1-\zeta)c} \end{bmatrix}\begin{bmatrix} dB^n \\ dB^s \\ d\zeta \\ d\alpha \end{bmatrix}.$$

Using A, we obtain the Jacobian determinant,

$$|A| = -\left(\frac{\theta q(\theta)\beta + (r+\delta)\mu}{\theta q(\theta)}\right)\left(\begin{array}{c}\frac{(r+\delta)\{y^n - \delta(\alpha+\eta B^n) - b\}}{(1-\gamma)} + \\ \frac{p(\theta q(\theta)+\delta)}{(1-p)\theta q(\theta)\gamma^2}(1-\gamma)[y^s - \delta\eta(B^s - B^n) - y^n]\,\theta q(\theta)\beta\end{array}\right).$$

Using equation (22), the above can be simplified as

$$|A| = -\frac{\left(\frac{\theta q(\theta)\beta + (r+\delta)\mu}{\theta q(\theta)}\right)\lambda_1\left((r+\delta+\theta q(\theta)\phi\beta) \; - \; \frac{\partial\phi}{\partial\gamma}\gamma(1-\gamma)\,\theta q(\theta)\beta\right)}{(1-\gamma)(r+\delta+\theta q(\theta)\phi\beta)},$$

where $\lambda_1 = (r+\delta)[y^n - \delta(\alpha+\eta B^n) - b]$, $\frac{\partial\phi}{\partial\gamma} = -\frac{p(\theta q(\theta)+\delta)}{(1-p)\theta q(\theta)\gamma^2} < 0$, $\left(\theta q(\theta)\right)' > 0$ and $-\mu = q'(\theta)\frac{\theta}{q(\theta)}$; with $0 < \mu < 1$, given the homogeneity assumption of the matching function. The first bracketed term on the right-hand-side of $|A|$ is positive. Since $\frac{\partial\phi}{\partial\gamma} < 0$, the term in the bracket is positive. Thus, the sign of $|A|$ depends on the second term, λ_1. But since the expected gain or value of a filled vacancy must be nonnegative, i.e. $y^n > \delta(\alpha+\eta B^n) + b$, then $\lambda_1 > 0$. The Jacobian is, therefore, negative, $|A| < 0$. For future reference we define

$$|A|_1 = \frac{\lambda_1\left((r+\delta+\theta q(\theta)\phi\beta) \; - \; \frac{\partial\phi}{\partial\gamma}\gamma(1-\gamma)\,\theta q(\theta)\beta\right)}{(1-\gamma)(r+\delta+\theta q(\theta)\phi\beta)},$$

where $|A|_1 > 0$ since $\lambda_1 > 0$ and $\frac{\partial\phi}{\partial\gamma} < 0$. This is used where the first bracketed term of $|A|$ cancels out or is used to arrive at another result. Also, note that $\frac{\partial\phi}{\partial\theta} = \frac{\delta(\gamma-p)(\theta q(\theta))'}{\gamma(1-p)[\theta q(\theta)]^2} > 0$ as long as $\gamma > p$. Using Cramer's rule, it is straightforward to derive the comparative statics for each of the policy parameters α, B^n, B^s and ζ based on the information set out above.

The impact of severance compensation B^n on market tightness, θ:

$$\frac{\partial\theta}{\partial B^n} = -\frac{(1-\beta)\delta\eta\theta q(\theta)}{[\theta q(\theta)\beta + \mu(r+\delta)](1-\zeta)c} < 0. \qquad (A7)$$

An increase in B^n unambiguously reduces market tightness since it induces an additional separation cost to the firm. A key thing to note is that without the strictness of EPL, i.e., if $\eta = 0$, firms can get away with severance payment through wage reduction. In this case changes in B^n has no effect on job creation as $\frac{\partial\theta}{\partial B^n} = 0$.

The impact of fixed separation cost α on market tightness, θ:

$$\frac{\partial\theta}{\partial\alpha} = -\frac{(1-\beta)\delta\theta q(\theta)}{[\theta q(\theta)\beta + \mu(r+\delta)](1-\zeta)c} < 0. \qquad (A8)$$

The impact of recruitment subsidy ζ on market tightness, θ:

$$sign\left(\frac{\partial\theta}{\partial\zeta}\right) = sign\left(\frac{(1-\beta)\{y^n - \delta(\alpha+\eta B^n) - b\}\theta q(\theta)}{[\theta q(\theta)\beta + \mu(r+\delta)](1-\zeta)^2 c}\right). \qquad (A9)$$

The above shows that, provided $y^n > \delta(\alpha + \eta B^n) + b$, $\frac{\partial\theta}{\partial\zeta}$ is unambiguously positive $\left(\frac{\partial\theta}{\partial\zeta} > 0\right)$.

The impact of recruitment subsidy ζ on the share of low-tech vacancies, ϕ:

$$sign\left(\frac{\partial\phi}{\partial\zeta}\right) =$$

$$sign\left(\frac{\lambda_1\left[\frac{\partial\theta}{\partial\zeta}\frac{\partial\phi}{\partial\theta}(r+\delta+\theta q(\theta)\phi\beta) + \frac{\partial\theta}{\partial\zeta}\frac{\partial\phi}{\partial\gamma}\big(\theta q(\theta)\big)'\phi\beta\gamma(1-\gamma)\right]}{|A|_1(1-\gamma)(r+\delta+\theta q(\theta)\phi\beta)}\right). \quad (A10)$$

Denominator is positive since $|A|_1 > 0$. However, since $\frac{\partial\theta}{\partial\zeta} > 0$, $\frac{\partial\phi}{\partial\gamma} < 0$ and $\frac{\partial\phi}{\partial\theta} > 0$, the sign of $\frac{\partial\phi}{\partial\zeta}$ is ambiguous. (We discuss this further in the text.)

The effect of severance compensation B^s on the share of low-tech vacancies, ϕ:

$$\frac{\partial\phi}{\partial B^s} = -\frac{\frac{\partial\phi}{\partial\gamma}(1-\gamma)\delta\eta(r+\delta+\theta q(\theta)\phi\beta)}{|A|_1} > 0. \qquad (A11)$$

The above equation is unambiguously positive since $\frac{\partial\phi}{\partial\gamma} < 0$.

The impact of B^n on the share of low-tech vacancies, ϕ:

$$sign\left(\frac{\partial\phi}{\partial B^n}\right) =$$

$$sign\left(\frac{\frac{\partial\phi}{\partial\gamma}[(r+\delta)+(1-\gamma)\theta q(\theta)\phi\beta]\delta\eta + \frac{\partial\theta}{\partial B^n}\left(\frac{\partial\phi}{\partial\theta}\lambda_2 + \frac{\partial\phi}{\partial\gamma}\lambda_3\right)}{|A|_1}\right), (A12)$$

where, $\lambda_2 = \frac{(r+\delta)\{y^n - \delta(\alpha+\eta B^n) - b\}}{(1-\gamma)} > 0$, by assumption. Also, by virtue of (22), in the text, $\lambda_3 = (1-\gamma)\{y^s - \delta\eta(B^s - B^n) - y^n\}\big(\theta q(\theta)\big)'\phi\beta > 0$. As the denominator of the above is positive, $|A|_1 > 0$, the sign of the derivation depends on the numerator. But given that, $\frac{\partial\theta}{\partial B^n} < 0$, $\frac{\partial\phi}{\partial\theta} > 0$ and $\frac{\partial\phi}{\partial\gamma} < 0$, then $\frac{\partial\phi}{\partial B^n}$ is somewhat ambiguous.

The effect of severance compensation B^s on the share of unskilled unemployed workers, γ:

$$\frac{\partial\gamma}{\partial B^s} = -\frac{(1-\gamma)\delta\eta(r+\delta+\theta q(\theta)\phi\beta)}{|A|_1} < 0. \qquad (A13)$$

The above equation is unambiguously negative, since $|A|_1 > 0$.

The effect of subsidy ζ on the share of unskilled unemployed workers γ:

$$sign\left(\frac{\partial\gamma}{\partial\zeta}\right) = sign\left(\frac{\frac{\partial\theta}{\partial\zeta}\left[\left(\theta q(\theta)\right)'\phi\beta \; + \; \frac{\partial\phi}{\partial\theta}\theta q(\theta)\beta\right]\gamma\lambda_1}{|\mathrm{A}|_1(r+\delta+\theta q(\theta)\phi\beta)}\right). \quad (A14)$$

The equation above is unambiguously positive since $\lambda_1 > 0$, $\frac{\partial\theta}{\partial\zeta} > 0$ and $\frac{\partial\phi}{\partial\theta} > 0$.

The impact of severance compensation B^n on the share of unskilled unemployed workers γ:

$$sign\left(\frac{\partial\gamma}{\partial B^n}\right) =$$

$$sign\left(\frac{[(r+\delta)+(1-\gamma)\theta q(\theta)\phi\beta]\delta\eta \; + \; \frac{\partial\theta}{\partial B^n}\lambda_4\left(\left(\theta q(\theta)\right)'\phi\beta \; + \; \frac{\partial\phi}{\partial\theta}\,\theta q(\theta)\beta\right)}{|A|_1}\right), (A15)$$

where $\lambda_4 = (1-\gamma)\{y^s - \delta\eta(B^s - B^n) - y^n\} > 0$. The first term of the numerator is positive, but due to the impact of B^n on job creation $\left(\frac{\partial\theta}{\partial B^n} < 0\right)$ and the fact that $\frac{\partial\phi}{\partial\theta} > 0$, the second term is negative, which makes $\frac{\partial\gamma}{\partial B^n}$ difficult to sign.

2A.4 Effects of Policies on Unemployment Rate

From equation (16) in the text we know that $u = u[\theta(B^n,\zeta,\alpha,X_i),\gamma(B^n,B^s,\zeta,\alpha,X_i)]$, where θ and γ are two intermediate variables directly determining u, but dependent on policy instruments as well as other exogenous variables, X_i. Again, we focus on the effect of each policy, setting all variations in $X_i = 0$. Using (16) we first show that,

$$\frac{\partial u}{\partial\theta} = -\frac{\delta(1-p)\left(\theta q(\theta)\right)'}{[\theta q(\theta)+\delta]^2(1-\gamma)} < 0. \quad (A16)$$

$$\frac{\partial u}{\partial\gamma} = \frac{\delta(1-p)}{[\theta q(\theta)+\delta](1-\gamma)^2} > 0. \quad (A17)$$

The effect of severance compensation B^n on unemployment rate, u:

Evaluation takes the form,

$$\frac{\partial u}{\partial B^n} = \frac{\partial u}{\partial\theta}\frac{\partial\theta}{\partial B^n} + \frac{\partial u}{\partial\gamma}\frac{\partial\gamma}{\partial B^n}.$$

which can be rewritten as,

$$sign\left(\frac{\partial u}{\partial B^n}\right) = sign\left(\frac{\delta(1-p)}{(\theta q(\theta)+\delta)(1-\gamma)^2}\frac{\partial\gamma}{\partial B^n} - \frac{\delta(1-p)(\theta q(\theta))'}{[\theta q(\theta)+\delta]^2(1-\gamma)}\frac{\partial\theta}{\partial B^n}\right). (A18)$$

Since $\frac{\partial\theta}{\partial B^n} < 0$, the last term on the right-hand-side is positive. However, due to the ambiguous sign of $\frac{\partial\gamma}{\partial B^n}$ in (*A*15), the overall effect of B^n on u is also ambiguous.

The effect of severance compensation B^s on unemployment rate, u:

This is evaluated using $\frac{\partial u}{\partial B^s} = \frac{\partial u}{\partial \theta}\frac{\partial \theta}{\partial B^s} + \frac{\partial u}{\partial \gamma}\frac{\partial \gamma}{\partial B^s}$. However, since $\frac{\partial \theta}{\partial B^s} = 0$ we have,

$$\frac{\partial u}{\partial B^s} = \frac{\delta(1-p)}{(\theta q(\theta)+\delta)(1-\gamma)^2}\frac{\partial \gamma}{\partial B^s} < 0. \qquad (A19)$$

As equation (A13) is negative, the above is also negative.

The effect of recruitment subsidy ζ on unemployment rate, u:

Combing relevant terms yields

$$sign\left(\frac{\partial u}{\partial \zeta}\right) = sign\left(\frac{\delta(1-p)}{(\theta q(\theta)+\delta)(1-\gamma)^2}\frac{\partial \gamma}{\partial \zeta} - \frac{\delta(1-p)(\theta q(\theta))'}{[\theta q(\theta)+\delta]^2(1-\gamma)}\frac{\partial \theta}{\partial \zeta}\right). \qquad (A20)$$

As $\frac{\partial \theta}{\partial \zeta} > 0$, the last term in the bracket is negative, suggesting that unemployment is decreasing in recruitment subsidy. However, since the first term on the right-hand-side is positive as $\frac{\partial \gamma}{\partial \zeta} > 0$, which implies that unemployment is increasing, the overall impact of subsidy on unemployment is ambiguous.

2B Tables and Figures

Table 2.1: Match output

Workers \ Jobs	**Low-tech (type *n*)**	**High-tech (type *s*)**
Unskilled (type *l*)	$x_l^n = y^n$	$x_l^s = 0$
Skilled (type *h*)	$x_h^n = y^n$	$x_h^s = y^s$

Table 2.2: Baseline calibration

Parameters	**Value**	**Source**
β	0.5	Pissarides (2000)
μ	$\mu = \beta$	Hosios (1990)
b	0.1	AV-02
r	0.05	AV-02
c	0.5	Dolado et al. (2009)
p	2/3	See text
δ	0.2	Dolado et al. (2009)
y^s	1.4	See text
y^n	1	AV-02
χ	2	See text
$B^s = B^n = \eta = \alpha = \zeta$	0	See text

Table 2.3: Comparative statics

		θ	γ	ϕ	u_l	u_h	u	w_l^n	w_h^n	w_h^s	$\theta q(\theta)$	$\phi\theta q(\theta)$
α	**Bench.**	1.4944	0.6975	0.8565	0.0872	0.0756	0.0833	0.9133	0.9474	1.1474	2.4449	2.0941
	0.1	1.4581	0.6989	0.8502	0.0888	0.0765	0.0847	0.8938	0.9306	1.1306	2.4151	2.0533
	0.25	1.4038	0.7010	0.8405	0.0913	0.0778	0.0868	0.8647	0.9056	1.1056	2.3696	1.9916
	0.5	1.3135	0.7048	0.8235	0.0958	0.0803	0.0906	0.8162	0.8646	1.0646	2.2921	1.8876
B^n	**Bench.**	1.4944	0.6975	0.8565	0.0872	0.0756	0.0833	0.9133	0.9474	1.1474	2.4449	2.0941
	0.1	1.4762	0.7010	0.8412	0.0891	0.0760	0.0848	0.8825	0.9211	1.1461	2.4300	2.0441
	0.25	1.4491	0.7060	0.8190	0.0921	0.0767	0.0870	0.8365	0.8816	1.1441	2.4075	1.9718
	0.5	1.4038	0.7140	0.7842	0.0972	0.0778	0.0907	0.7599	0.8160	1.1410	2.3696	1.8582
B^s	**Bench.**	1.4944	0.6975	0.8565	0.0872	0.0756	0.0833	0.9133	0.9474	1.1474	2.4449	2.0941
	0.1	1.4944	0.6947	0.8692	0.0860	0.0756	0.0826	0.9143	0.9426	1.1176	2.4449	2.1251
	0.25	1.4944	0.6902	0.8892	0.0842	0.0756	0.0814	0.9159	0.9362	1.0737	2.4449	2.1739
	0.5	1.4944	0.6824	0.9253	0.0812	0.0756	0.0794	0.9185	0.9282	1.0032	2.4449	2.2622
ζ	**Bench.**	1.4944	0.6975	0.8565	0.0872	0.0756	0.0833	0.9133	0.9474	1.1474	2.4449	2.0941
	0.1	1.6763	0.7028	0.8341	0.0848	0.0717	0.0804	0.9154	0.9550	1.1550	2.5895	2.1597
	0.25	2.0427	0.7117	0.7968	0.0807	0.0654	0.0756	0.9190	0.9676	1.1676	2.8585	2.2776
	0.5	3.1559	0.7312	0.7205	0.0725	0.0533	0.0661	0.9265	0.9935	1.1935	3.5530	2.5598

Table 2.4: Labour market outcomes (fixed and flexible wage rates)

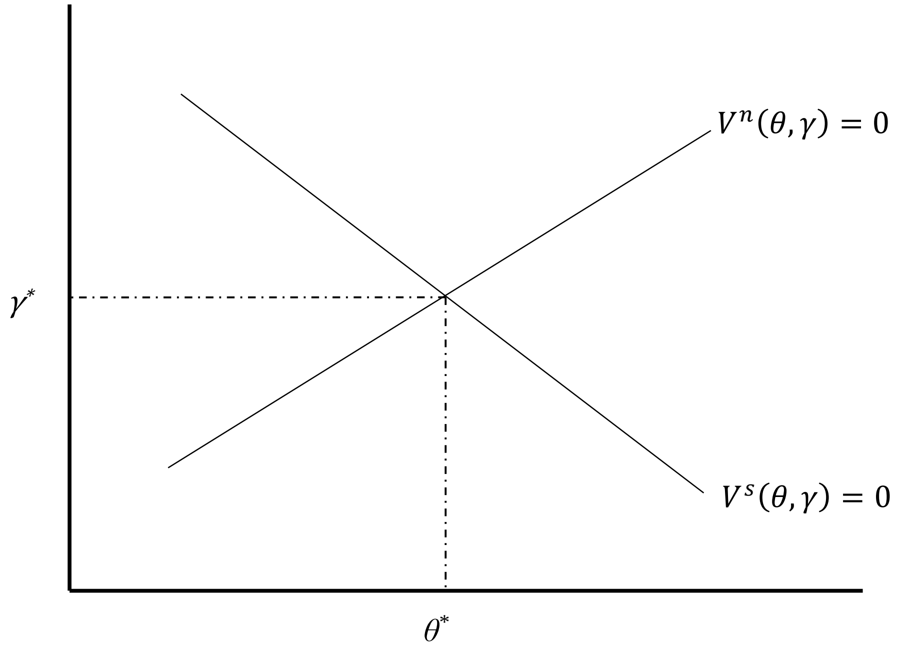
	Model	$\boldsymbol{\theta}$	$\boldsymbol{\gamma}$	$\boldsymbol{\phi}$	$\boldsymbol{u_l}$	$\boldsymbol{u_h}$	$\boldsymbol{u}$
Bench (*)	(1) (**)	1.4944	0.6975	0.8565	0.0872	0.0756	0.0833
	(2) (***)	1.4944	0.6975	0.8565	0.0872	0.0756	0.0833
$\alpha = 0.1$	(1)	1.4581	0.6989	0.8502	0.0888	0.0765	0.0847
	(2)	0.8668	0.7498	0.6316	0.1453	0.0970	0.1292
$B^n = 0.1$	(1)	1.4762	0.7010	0.8412	0.0891	0.0760	0.0848
	(2)	0.6394	0.8021	0.4300	0.2253	0.1112	0.1873
$B^s = 0.1$	(1)	1.4944	0.6947	0.8692	0.0860	0.0756	0.0826
	(2)	1.4544	0.6673	0.9967	0.0766	0.0768	0.0767
$\zeta = 0.1$	(1)	1.6763	0.7028	0.8341	0.0848	0.0717	0.0804
	(2)	1.8449	0.6975	0.8576	0.0791	0.0686	0.0756

*Benchmark results without policy $\alpha = B^n = B^s = \zeta = \eta = 0$.
** Results from model with flexible wage.
** Results from model with Fixed wage.

Table 2.5: Robustness check

		Var.	y^s 1.35	y^s 1.40	y^s 1.45	y^n 0.95	y^n 1	y^n 1.05
$\boldsymbol{B^n}$	**0.1**	$\%\Delta u$	1.82	1.73	1.65	1.71	1.73	1.77
		$\%\Delta\phi$	-1.96	-1.79	-1.66	-1.69	-1.79	-1.93
		$\%\Delta\gamma$	0.57	0.49	0.43	0.44	0.49	0.57
		$\%\Delta\theta$	-1.21	-1.21	-1.21	-1.29	-1.21	-1.15
	0.25	$\%\Delta u$	4.60	4.36	4.17	4.32	4.36	4.47
		$\%\Delta\phi$	-4.78	-4.38	-4.06	-4.16	-4.38	-4.70
		$\%\Delta\gamma$	1.41	1.22	1.07	1.07	1.22	1.41
		$\%\Delta\theta$	-3.03	-3.03	-3.03	-3.22	-3.03	-2.87
$\boldsymbol{B^s}$	**0.1**	$\%\Delta u$	-1.04	-0.93	-0.85	-0.85	-0.93	-1.03
		$\%\Delta\phi$	1.68	1.48	1.33	1.34	1.48	1.67
		$\%\Delta\gamma$	-0.49	-0.41	-0.35	-0.34	-0.41	-0.49
		$\%\Delta\theta$	0.00	0.00	0.00	0.00	0.00	0.00
	0.25	$\%\Delta u$	-2.62	-2.35	-2.13	-2.14	-2.35	-2.60
		$\%\Delta\phi$	4.34	3.81	3.40	3.43	3.81	4.32
		$\%\Delta\gamma$	-1.25	-1.04	-0.89	-0.88	-1.04	-1.26
		$\%\Delta\theta$	0.00	0.00	0.00	0.00	0.00	0.00
$\boldsymbol{\alpha}$	**0.1**	$\%\Delta u$	1.59	1.61	1.62	1.73	1.61	1.50
		$\%\Delta\phi$	-0.72	-0.74	-0.76	-0.81	-0.74	-0.67
		$\%\Delta\gamma$	0.21	0.20	0.19	0.20	0.20	0.20
		$\%\Delta\theta$	-2.43	-2.43	-2.43	-2.58	-2.43	-2.29
	0.25	$\%\Delta u$	4.11	4.15	4.18	4.46	4.15	3.87
		$\%\Delta\phi$	-1.82	-1.87	-1.92	-2.07	-1.87	-1.70
		$\%\Delta\gamma$	0.53	0.51	0.49	0.52	0.51	0.50
		$\%\Delta\theta$	-6.06	-6.06	-6.06	-6.43	-6.06	-5.73
$\boldsymbol{\zeta}$	**0.1**	$\%\Delta u$	-3.54	-3.51	-3.48	-3.48	-3.51	-3.54
		$\%\Delta\phi$	-2.65	-2.62	-2.59	-2.58	-2.62	-2.66
		$\%\Delta\gamma$	0.79	0.75	0.72	0.71	0.75	0.80
		$\%\Delta\theta$	12.17	12.17	12.17	12.21	12.17	12.15
	0.25	$\%\Delta u$	-9.33	-9.26	-9.19	-9.19	-9.26	-9.34
		$\%\Delta\phi$	-7.05	-6.97	-6.90	-6.88	-6.97	-7.06
		$\%\Delta\gamma$	2.15	2.04	1.94	1.91	2.04	2.18
		$\%\Delta\theta$	36.69	36.69	36.69	36.79	36.69	36.60

Figure 2.1: Joint determination of $\boldsymbol{\theta}$ and $\boldsymbol{\gamma}$



Chapter 3. Fiscal and Labour Market Policies in a General Equilibrium Model with Search and Matching Frictions

3.1 Introduction

The economic crisis that began in 2007/2008 attracted extensive attention in the literature, both because of the suddenness in output collapse and the consequent rise in unemployment rate across countries and because of the governments' aggressive fiscal response used to stimulate aggregate demand and foster job creation. In the US, the GDP contracted substantially with the unemployment rate rising to a record high, since the 1980s, of approximately 10 percent in 2009. To restore economic activities, the US government signed into law the American Recovery and Reinvestment Act, designed to appropriate financial packages to stabilise economic activity by stimulating aggregate demand. As documented by Ahrens (2009) and ILO (2009), approximately 1.4 percent of the world's GDP was directed towards fiscal stimulus packages, with countries such as Germany and Spain respectively spending roughly 2.8 and 0.9 percent of the country's GDP.[1]

At the same time, several labour market measures and reforms have been implemented across different countries. Notable examples are the US Hiring Incentive to Restore Employment Act signed into law in March 2010 to provide incentives for firms to increase hiring and the extension of benefits insurance policy from 26 to 99 weeks to provide income support for the unemployed (Hagedorn, Karahan, Manovskii, & Mitman, 2015). Other countries like Spain whose unemployment rate more than doubled (from approximately 9 to 25 percent) between the first quarter of 2008 and the same quarter in 2014, equally employed alternative policy measures to combat rising unemployment. In both 2010 and 2012 the Spanish government engaged in a comprehensive labour market reforms that led to the reduction of monetary compensation for (sudden) unfair dismissal and the removal of additional cost incurred by firms between the effective date of dismissal and the final court ruling, thus giving firms better flexibility (OECD, 2014). In Ireland, the government introduced subsidies to encourage employment as well as cut down on unemployment insurance benefits per unemployed worker, all aimed at reducing the country's unemployment rate which had also increased to about 12 percent in 2009 from 5 percent in 2007 (Heyes, 2013).

While many recent studies have examined the effects of fiscal policies on economic outcomes, there remains little consensus on their effectiveness. This is in part due to the difficulty of isolating the *direct* effects of fiscal stimuli on economic variables (Batini et al., 2014). Empirical studies suggest that the degree of impact of fiscal spending depends on several factors (Auerbach & Gorodnichenko, 2013; Blanchard & Leigh, 2013; Corsetti, Meier, & Muller, 2012; Ilzetzki, Mendoza, & Végh, 2013; Kwan, 2007, among others). For example, Blanchard and

[1] See Ahrens (2009) for further evidence of *fiscal stimulus packages undertaken by 32 national governments* across the world.

Leigh find that the initial level of household debt, among other variables, significantly influences the outcome of fiscal spending, contending that the forecast errors at the early stage of the crisis were principally due to poor estimation of fiscal multipliers. Using a dataset for 44 countries (consisting of developed and developing countries), Ilzetzki et al. find that factors such as the exchange rate system and degree of openness play a fundamental role in shaping the effects of fiscal multipliers. In their paper, Corsetti et al. find that the level of public finance (among other factors) matters for fiscal multipliers. Kwan finds that if public and private consumptions are highly substitutable, government spending is likely to result in a negative output multiplier. Labour market rigidities have also been identified as determining the size of fiscal multipliers (Auerbach & Gorodnichenko, 2013; Batini et al., 2014).

From the theoretical front, the assessment of the effects of fiscal policies also remains contentious. Using a model with monopolistic competition, Molana and Zhang (2001) demonstrates that an increase in fiscal spending can generate an output multiplier larger than if the degree of firms' market power is allowed to adjust. The authors show that, via its aggregate demand effect, an increase in fiscal consumption expenditure leads to a reduction in firms' market power, which, in turn, increases market participation and the multiplier effect of fiscal expansion. Comparing government expenditure and tax cut, Fernández-Villaverde (2010) shows that, in the presence of financial frictions, an increase in the former is likely to be more effective in boosting economic activities. The nature of offsetting fiscal instruments also affects the effectiveness of fiscal policies (Baxter & King, 1993; Burnside, Eichenbaum, & Fisher, 2004; Uhlig, 2010). In particular, Baxter and King demonstrate that the distortionary effect of income tax can lead to negative output multiplier compared to traditional lump-sum tax financing. Besides concentrating on the output (and passively on the labour market) effect of fiscal expansion, a common shortcoming of these studies is the assumption of a perfect labour market, which disregards the issue of unemployment – one of the greatest consequences of the last economic crisis (Bova, Kolerus, & Tapsoba, 2015; Salgado, Figari, Sutherland, & Tumino, 2014).

Several recent studies papers have attempted to fill this gap by explicitly considering the labour market effects of fiscal policies and how its structure drives fiscal multipliers (Cantore et al., 2014; Faia, Lechthaler, & Merkl, 2013; Mayer, Moyen, & Stähler, 2010; Monacelli et al., 2010; Yuan & Li, 2000). Monacelli et al. study the transmission mechanisms of government consumption spending in a dynamic stochastic general equilibrium (DSGE) model with search and matching friction in the labour market. They show that the surplus of a job match plays a key role in determining the labour market impacts of fiscal policy shock. In particular, the show that an increase in government consumption spending leads to an increase in the match surplus and, in turn, induces firms to create more vacancies. The consequent tightening in the labour market leads to higher job finding rate and employment, but the implied fiscal multiplier effects are small. Mayer et al. also find small multiplier effect on unemployment but argues that a positive shock to government consumption can only result in a higher job creation and employment if the shock is highly persistent. Campolmi et al. (2011a) and Brückner and Pappa (2012) extend their models to include labour force participation. The latter conclude that fiscal spending induces labour participation which can potentially lead to a higher unemployment. By contrast, Campolmi et al., (2011a) find that labour participation plays a limited role in shaping the effects of fiscal stimulus. They show further that even when financed by lump-sum taxes, government consumption spending can potentially lead to a negative employment multiplier. Cantore et al. emphasise the roles of model features (deep habits and the structure of production technology) in producing large fiscal multiplier which matches empirical estimates.

The role of the labour market in shaping economic performance has been emphasised in the literature (Nickell & Layard, 1999; Walsh, 2005). Consequently, policies associated with the market influence the extent to which shocks impact on economic variables, including labour market variables such as unemployment, vacancy creation rate among others (Auerbach & Gorodnichenko, 2013; Pissarides, 2001). Most researchers (e.g. Blanchard & Wolfers, 2000; Nickell, et al., 2005, among others) argue that the heterogeneity in labour market institutions in countries like the US and those in the EU can explain the existence of persistently high unemployment rate in the latter; while the US is known for its market flexibility, most EU countries are characterised by strict labour policies which bring about market rigidity – the so-called Eurosclerosis. In the presence of search and matching frictions, the responses of labour market variables and the economy as a whole to aggregate shocks depend on several important factors, including the (i) the workers' valuation of unemployment, (ii) the ability of firms to terminate employment contract without incurring huge cost of separation, and (iii) the size of a match surplus which drives firms' vacancy creation decision. These, in turn, depend crucially on the nature of regulations governing the labour market. When these regulations are unfavourable (rigid) they significantly alter the way the labour market adjusts to shocks (Blanchard, Jaumotte, & Loungani, 2013).

The purpose of this chapter is to study the effects of fiscal policies on the labour market. In particular, we investigate how labour market institutions affect the long-run structure of the economy and the channels through which this shapes the transmission of fiscal policies. To this end, we construct a real business cycle DSGE[2] model with labour market frictions (Pissarides, 2000). We consider labour market institutions in the form of firing penalty (that incorporates a

[2] Generally, there are two main classes of DSGE models that introduce search and matching friction in the labour market: the New Keynesian (NK) (Blanchard & Galí, 2010; Krause & Lubik, 2007; Walsh, 2005; Zanetti, 2011) and the real business cycle (RBC) (Andolfatto, 1996; Burda & Weder, 2016; Krause & Lubik, 2010; Merz, 1995; Monacelli et al., 2010; Yuan & Li, 2000). The key difference between these two classes of models is their emphasis on the sources and the propagation mechanisms of shocks (Duarte, 2015). However, as noted by Uhlig (2010), the long run characteristics of typical NK and RBC models are almost the same. DSGE models are often criticised for the complexity of their solutions (Fernandez-Villaverde et al., 2016; Flotho, 2009). Although we do not consider this since we interested in fiscal policies and labour market frictions, the models have also been criticised for not incorporating financial frictions (García, 2011). Despite these, DSGE models continue to serve as powerful tools for modern macroeconomics within policy and academic environments (Sbordone et al., 2010; Tovar, 2009).

fixed firing cost and severance transfer to workers), unemployment insurance benefits and distortionary labour tax. In contrast with many existing studies, we distinguish between traditional government expenditure and labour market-oriented policies. The latter consists of recruitment and employment tax subsidies (active labour market policy (ALMP) measures deployed during the crisis period).[3] While recruitment subsidies are channelled towards reducing the cost of vacancy creation, tax subsidies are granted only when job matches have been consummated with a view to reducing labour costs. Furthermore, we allow for utility-enhancing as opposed to wasteful government consumption along the line proposed by, e.g., Aschauer (1985), Molana and Zhang (2001) and Kwan (2007).

The model features two vertically integrated production sectors (an intermediate and final good sector). The intermediate sector, characterised by a monopolistically competitive structure in its product market, produces horizontally differentiated goods using capital and labour factor inputs. The recruitment of workers is time consuming and costly as reflected by search and matching frictions. Employment is modelled to adjust both at intensive (hours worked per worker) and extensive (number of workers employed) margins to enable us to capture government spending effects on the labour market as emphasised by Yuan and Li (2000). Differentiated goods are assembled by the final good sector to produce homogenous *final good* used by the household and government for consumption purposes as well as for capital formation. We adopt the representative household construct of Andolfatto (1996) and Merz (1995) and assume that members of this household pool their recourses to insure each other against earning uncertainty. The household maximises its utility by choosing the paths for consumption and capital stock. Capital serves a dual purpose as a store of wealth for the household and as a productive factor. The government sets rules regarding employment and has to satisfy a balanced budget each period. It raises revenue through taxes levied on labour and other household incomes and the penalties imposed on firms upon job separations. These are in turn spent on own consumption, active labour market policies and the provision of social protections for the unemployed through unemployment benefits insurance.

We examine the long-run and dynamic properties of the model numerically. We find that, in the long-run, through their effects on cost hiring, ALMPs improve economic activity, whereas higher rigidities in the labour market reduce it. Government consumption spending also raises economic activity through its aggregate demand effect, resulting in increased hiring and lower unemployment. The effectiveness of this, however, depends on the degree of substitutability between private and government consumption. Specifically, we find that when associated with higher degree of substitutability the impact of a rise in government consumption spending on output and job creation reduces. The reason is that, by raising private utility, the household spends less on consumption as government consumption spending rises. Thus, the increase in

[3] Faia, Lechthaler, and Merkl (2013) emphasised the fact that large percentage of fiscal stimulus policies utilised during the last economic crisis were channelled towards job creation

the latter is partly offset by the decrease in the former, reducing the impact on aggregate demand and the incentives for hiring.

We argue that if labour market institutions are rigid, the incentives to create vacancies and supply more hours to work per employee are enhanced in response to government consumption expansion. The central mechanism underlying these results is the effects of the individual labour market policies on the initial sizes of match surplus and the household's budget (or the disposal income (HDI)). By increasing the cost of employment and reducing productivity, higher rigidity leads to a decrease in the sizes of match surplus and HDI, making firms and households more sensitive to shocks. The idea is that – for the firms – when the size of match surplus is small, a positive shock which raises productivity leads to a larger percentage increase the values of a match (Hagedorn & Manovskii, 2008; Hornstein, et al., 2005; Shimer, 2005). This requires that vacancies – and by implication, hiring – must adjust more rapidly to equalise the value of creating an additional vacancy to the marginal cost of creating the vacancy. Thus, the resulting effect is a rapid adjustment in vacancy creation which in turn leads to a more dramatic response in extensive margin employment. The ultimate impact on output now depends on how each institution shapes the responses of capital accumulation and hours supplied per worker to the government consumption expansion. Given that higher rigidity also reduces the HDI in the long-run, the decrease in consumption and capital are larger, in percentage terms, following a positive government consumption shock, as the household anticipates an additional increase in tax obligations. The decrease in consumption further amplifies supply of hours per worker. Thus, even though the response of capital accumulation is weakened, the stronger response in intensive and extensive margins of employment sustains output response. In terms of its influence on shock propagation, we find that severance compensation has virtually the same effect, quantitatively, as fixed firing cost.[4] However, when compared to the effects of benefits insurance and distortionary tax on the transmission of shocks, both are quantitatively small.

Finally, we compare the labour market effects of lump-sum vs distortionary labour tax-financed fiscal spending. Our result suggests that, regardless of the financing option, only labour market-oriented fiscal spending instruments remain effective in boosting employment compared to the traditional fiscal expenditure. Government consumption expansion produces negative output and employment multipliers when financed by a distortionary tax, in line with Campolmi et al. (2011a). Our results also show that, in the presence of rigid institution, recruitment subsidy is the only potent fiscal instrument that can generate output and employment multipliers that are above unity. Another finding from this study is that the presence of distortionary labour tax magnifies severance deduction from wage, whereas the strengthening of worker bargaining power reduces it. And provided there is some degree of strictness in its enforcement, severance

[4] Zanetti (2011a) show that fixed separation cost has significant implications for the volatility of output and employment in a study which focuses on the transmission of monetary policy shocks.

compensation can have real implication for job creation decision within a general equilibrium model, especially in the long run.

Our study closely relates to Monacelli et al. (2010) and Yuan and Li (2000). Monacelli et al., however, excludes the intensive margin of employment, which turns out to be an important channel through which the effects of government spending shocks can be transmitted. While Yuan and Li consider the intensive margin employment in their framework, they assume that its supply is determined at the household level. Instead, we let firms and their employees negotiate over the hours supply in line with recent studies (for example, Trigari, 2006; Faccini et al., 2013). This study also complements Campolmi et al. (2011b). However, that study ignores the implications of capital which provides an additional channel for the propagation of shocks (Baxter & King, 1993; den Haan, Ramey, & Watson, 2000; Heer & Maußner, 2010; Monacelli et al., 2010). Lastly, because this chapter offers further explanations about the influence of institutions on the dynamics of an economy, it contributes to the literature on labour market rigidities, such as Zanetti (2011a) and Dabusinskas, Konya, and Millard (2016). However, while Zanetti focuses on how institutions shape monetary policy transmission mechanisms, Dabusinskas et al. emphasise the implications of labour market rigidity for financial shock within an open economy framework.

The remaining part of this chapter proceeds as follows: Section 3.2 presents the baseline DSGE model frictional search and matching labour market. In sections 3.3, 3.4 and 3.5 we discuss the market clearing conditions, model calibration strategy and the role of match surplus. The steady state (long-run) properties of the model and the dynamic results are presented in sections 3.6 and 3.7. In Section 3.7, we consider the effects of labour market institutions on shock propagation, the role of subsidies and substitutability between private and public consumption, and effects of alternative government financing options on the economy as well as fiscal multipliers. The final section (3.8) concludes this chapter.

3.2 The Model

The main structure of the model economy closely follows Faccini et al. (2013), Krause and Lubik (2010) and Trigari (2006). However, unlike these authors, we concentrate on labour market institutions and fiscal stimulus policies. The choice of this model is driven by the fact that employment can be studied both at intensive (hours per worker) and extensive (number of employed workers) margin, unlike most other papers that focus solely on extensive margin. The economy we model here is made up of four types of agents: a representative household, two vertically integrated production sectors (an intermediate and final good sector) and a government. The household consumes, saves through investment in capital and supplies labour. The final good sector produces a unique final output using intermediate varieties as inputs. The final output is sold in a competitive market to the household for consumption and investment purposes and to the government for its consumption. The Intermediate sector has monopoly power in the product market and seeks to maximise profits employing workers and renting capital for the production of intermediate varieties. The hiring of workers is costly and time-consuming in the sense of search and matching frictions and job matches are dissolved at a constant rate determined exogenously (Hall, 2005). We assume *full labour market participation* so that workers who lose their jobs immediately commences search (Blanchard & Gali, 2010), rather than wait until next period (Dabusinskas et al., 2016). Both wages and hours worked by employed are determined through efficient Nash bargain (Trigari, 2006). The government implements employment policies through the provision of active labour market policies and unemployment benefits insurance and consumes final good, which is assumed to enhance household utility. It operates a balanced budget and finances its expenditures using revenues generated through taxes levied on labour and other household incomes and the penalties imposed on firms upon job separations.

3.2.1 The Representative Household

We model a representative household composed of a continuum of members whose measure is normalised to one. The household members are either employed or unemployed. We assume that at any given time t a share N_t of the household members are employed by firms. Normalising the number of firms to unity and denoting by n_{it} the number of workers employed in firm $i \in [0,1]$, it follows that $N_t = \int_0^1 n_{it}\, di$ in each period. In line with the literature (Andolfatto, 1996; Merz, 1995), we assume members of household completely insure each other against earning uncertainty and unemployment risks.[5] The household is assumed to have an infinite lifespan[6] and its objective is to maximise an expected lifetime utility, given by

$$E_t \sum_{s=0}^{\infty} \beta^s \left[\frac{(C_{t+s}^e)^{1-\alpha_c}}{1-\alpha_c} - A \int_0^1 \frac{n_{it+s}\, h_{it+s}^{1+\alpha_h}}{1+\alpha_h} di \right], \tag{1}$$

where E_t represents the conditional expectation operator (based on information available at time t). The parameters $\beta \in [0,1]$ and $A > 0$ respectively represent the household's subjective discount factor and the measure of the disutility of working. $1/\alpha_c$ captures the intertemporal elasticity of substitution and $\alpha_h > 0$ is the inverse of the Frisch elasticity of labour supply. The variable h_{it} is the hours supplied per worker at firm i. The household is assumed to derive utility from government consumption (Kollintzas & Vassilatos, 2000; Molana & Zhang, 2001). Thus, $C_{t+s}^e = C_{t+s} + \varphi G_{t+s}$ represents the *effective* household consumption, where C_t and G_t denote household (private) and government (public) consumptions, respectively. The measure $0 < \varphi < 1$ is the degree of substitutability that governs the extent to which the household directly derives utility for a given level of government consumption. When $\varphi = 0$ government consumption spending is interpreted as wasteful from the viewpoint of the household as it yields

[5] This assumption enables us to circumvent the complications which could arise due to heterogeneity among members. The aggregate number of the unemployed is defined below.
[6] See Chapter 2, page 18, of this thesis for the justification of this assumption.

no utility, and $\varphi = 1$ implies that both household and government consumptions are perfect substitutes.[7]

Since all members pool their incomes, at any time $t+s$, the intertemporal budget constraint of the household is given by

$$C_{t+s} + I_{t+s} + T_{t+s} = \int_0^1 n_{it+s}(1-\tau_{t+s})w_{it+s}h_{it+s}di$$
$$+(1-N_{t+s})b_{t+s} + \eta N_{t+s}B + N_{t+s}\zeta^w_{t+s} + r_{t+s}K_{t+s} + \Pi_{t+s}, \qquad (2)$$

where I_t, Π_t and K_t denote household's investment, capital stock and profit income, $\int_0^1 n_{it}(1-\tau_t)w_{it}h_{it}di$ and $(1-n_t)b_t$ are real after-tax labour income and unemployment benefits received by the aggregate household members who are left unemployed in at time t, r_t is the real return rate on capital held during time t. The policy instruments T_t and τ_t represent lump sum tax and the tax rate on labour income (distortionary tax). We assume that a worker whose employment is severed at time t receives severance compensation, B, from the firm where he or she was employed. Both B and τ are common to all workers. Therefore, the aggregate severance compensation received by the fraction of household members who lost their job at any time t is $\eta N_t B$; where $\eta > 0$ denotes an exogenous job separation rate (Faccini, Millard, & Zanetti, 2013). Additionally, following Pissarides (2000) and Zanetti (2011b), we assume that each employed worker receives tax subsidy given by ζ^w_t so that $\zeta^w_t N_t$ is the total sum received by household members in employment.[8] Capital stock evolves according to

$$K_{t+s+1} = I_{t+s} + (1-\delta)K_{t+s}, \qquad (3)$$

where δ is the constant capital depreciation rate.

Given the above, the household's chooses the optimal paths of consumption and capital stock $\{C_{t+s}, K_{t+s+1}\}^\infty_{s=0}$ in order to maximise the utility subject to the budget constraint taking account of the definition of effective consumption and the law of motion for capital, and treating as given: the initial value of capital K_0; policy instruments $\{T_{t+s}, \tau_{t+s}, b_{t+s}, \zeta^w_{t+s}\}^\infty_{s=0}$; aggregate profits received from firms $\{\Pi_{t+s}\}^\infty_{s=0}$; real wage and real interest rate $\{w_{t+s}, r_{t+s}\}^\infty_{s=0}$, and the hours supplied per worker $\{h_{t+s}\}^\infty_{s=0}$. Denoting the Lagrange multiplier associated with the household's budget constraint by Λ_t, the first order conditions resulting from maximisation, setting $s = 0$, are given by

$$\Lambda_t = (C_t + \varphi G_t)^{-\alpha_c}, \qquad (4)$$
$$\Lambda_t = \beta E_t[\Lambda_{t+1}(1 + r_{t+1} - \delta)]. \qquad (5)$$

Equations (4) and (5) respectively describe the representative household's marginal utility of the effective consumption and the standard Euler condition governing the optimal consumption path. For later use it is convenient to define $R_{t+s} \equiv 1 + r_{t+s} - \delta$, the real payoff of capital at time $t+s$, and rewrite the Euler condition (5) as $1 = E_t[\lambda_{t+s}R_{t+s}]$, where $\lambda_{t+s} =$

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[7] There is also a possibility that $\varphi < 0$, in which case government and private consumptions are assumed to be complement Kollintzas and Vassilatos (2000).

[8] Note that Pissarides (2000) and Zanetti (2011b) consider the effects of tax subsidy within partial equilibrium framework, unlike this model.

$\beta \prod_{j=1}^{s} \left(\frac{\Lambda_{t+j}}{\Lambda_{t+j-1}}\right) \equiv \beta \left(\frac{\Lambda_{t+s}}{\Lambda_t}\right)$ denotes the *stochastic discount factor* or the marginal rate of substitution of consumption which governs the rate at which the household is willing to substitute between consumption time t and $t+s$.

3.2.2 The Final Good Sector

We assume that this sector is perfectly competitive and uses all the varieties of the intermediate good as inputs to produce a unique final good, which can be used for household and government consumptions as well as for capital formation.[9] For simplicity, the production of final output is done *costlessly in the sense that it uses neither labour nor capital*. The aggregate production function of the sector is represented by a constant returns to scale technology,

$$Y_t = \left[\int_0^1 y_{it}^{\frac{\mathcal{E}_t - 1}{\mathcal{E}_t}} di\right]^{\frac{\mathcal{E}_t}{\mathcal{E}_t - 1}}, \tag{6}$$

where y_{it} represents intermediate varieties indexed by $i \in [0,1]$ and $\mathcal{E}_t > 1$ is the elasticity of substitution across input varieties, with a higher value of $\mathcal{E}_t$ implying greater substitutability. At any given time, the sector takes the price of final good P_t and input variety prices p_{it} as given and chooses y_{it} to maximise its profit, given by

$$\Pi_t^Y = P_t Y_t - \int_0^1 p_{it} y_{it} \, di, \tag{7}$$

subject to (6). Profit maximisation implies a downward sloping demand curve for each intermediate variety,

$$y_{it} = \left(\frac{p_{it}}{P_t}\right)^{-\mathcal{E}_t} Y_t. \tag{8}$$

Given perfect competition, profits are driven to zero in each period, $\Pi_t^Y = 0$. The price index P_t dual to (6) can, therefore, be derived as,

$$P_t = \left[\int_0^1 p_{it}^{(1-\mathcal{E}_t)} di\right]^{\frac{1}{1-\mathcal{E}_t}}. \tag{9}$$

3.2.3 The Intermediate Sector (Labour Market)

The labour market is characterised by search and matching frictions which describe job finding and vacancy filling activities of workers and firms. As is common within search literature, we let the meeting process between the job searching unemployed workers and vacancy filling firms be governed by a matching technology given by Cobb-Douglas function,

$$M\,(U_t, V_t) = \chi U_t^{\gamma} V_t^{1-\gamma}, \tag{10}$$

[9] This is a standard approach in the literature, especially if one is interested in investigating the effects of demand or mark-up shock as in Lubik (2009) and Krause and Lubik (2010). It is possible to let the household directly aggregate the differentiated varieties for its consumption and investment purposes without the intermediation of the final good sector as in Krause and Lubik. Doing so, however, would not alter the qualitative nature of our results.

where $V_t = \int_0^1 v_{it} di$ denotes aggregate vacancies, $\chi > 0$ captures the efficiency of the matching process and $\gamma > 0$ is the elasticity of match with respect to unemployment. The aggregate number of job searching workers – formally defined later – at time t is given U_t. The matching function exhibits the usual properties: increasing in both arguments, concave and homogeneous of degree one (Petrongolo & Pissarides, 2001; Pissarides, 2000). It is useful to define $\theta_t = {}^{V_t}/_{U_t}$ the measure of the degree of market tightness. Using (10), the job market transition rates: the rate with which a firm with vacancy meets an unemployed worker (vacancy filling rate) and that an unemployed worker meets a vacant job (job finding rate) can be defined, respectively, as

$$q_t^f = \frac{M\,(U_t, V_t)}{V_t} = \chi {\theta_t}^{-\gamma}, \tag{11}$$

and

$$q_t^w = \frac{V_t}{U_t} \frac{M\,(U_t, V_t)}{V_t} = \chi {\theta_t}^{1-\gamma}. \tag{12}$$

Both the vacancy filling and the job finding rates depend solely on the degree of market tightness: $dq_t^f / d\theta_t < 0$ and $dq_t^w / d\theta_t > 0$. The inverse of these rates, $\left[q_t^f\right]^{-1}$ and $[q_t^w]^{-1}$, respectively yield the mean duration of vacancies and unemployment spell. Both firms and workers take these probabilities as given. The dependence of q^f and q^w on θ generates externalities because it alters the meeting rate of other agents. In particular, for an additional unemployed worker (vacancy), more agents are searching on the same side of the market, thus creating *congestion* or negative externalities, since it reduces the probability of locating potential trading partners for other job seeking workers (vacancy filling firms). By contrast, when fewer agents are searching from the same side of the market, positive externalities arise because it increases the probability of being matched with a potential partner. As stressed by Hosios (1990) and Pissarides (2000), both the job seekers and firms ignore these externalities created by their actions, giving rise to inefficiency search. However, Hosios shows that by equating each party's share of the surplus of a job match to their respective contributions to the matching is a sufficient condition for the two opposite externalities to cancel out.

3.2.3.1 Demand Side in the Labour Market

Labour is employed directly by firms producing the intermediate varieties.[10] These firms operate under monopolistically competitive conditions in their product market, as governed by the horizontally differentiated nature of the varieties. During each period, firm $i, i \in [0,1]$, produces one variety using the following production function,

[10] Another possibility is to allow for labour market intermediation, where an agency hires workers and sell their services to production sector (e.g. de Walque et al., 2009). Note that, either way, it can be shown that the conclusions reached in this these will not differ qualitatively.

$$y_{it} = z_t \left(\frac{n_{it}h_{it}}{\phi}\right)^{\phi} \left(\frac{k_{it}}{1-\phi}\right)^{1-\phi}, \tag{13}$$

where $\phi \in (0,1)$ is the elasticity of output with respect to labour input, $n_{it}h_{it}$, and k_{it} is the stock of capital used as input at firm i. The variable z_t is the total factor productivity, assumed to be common to all firms and defined by an autoregressive process of order one (AR(1)):

$$\log z_t = \rho_z \log z_{t-1} + \psi_{zt}, \tag{14}$$

where $\rho_z \in (0,1)$ is an autoregressive parameter which measures the persistence of the AR(1) process and $\psi_{zt} \sim WN(0, \sigma_z^2)$. The higher is the value of ρ_z, the more persistence is the AR process, and when $\rho_z = 1$ the variance of productivity factor becomes infinite in which case the AR(1) process is non-stationary.

We follow Blanchard and Galí (2010) and Faccini et al. (2013) and assume that newly-matched workers become productive in the same period they are matched. This requires that, at any given point in time, employment at each firm evolves according to

$$n_{it} = (1-\eta)n_{it-1} + q_t^f v_{it}, \tag{15}$$

where $q_t^f v_{it} = m_i(u_{it}, v_{it})$ is the number of new matches in firm *i*. As implied by equation (15), employment at any time period comprises of the workers who are already in employment and survive separation from the previous period, $(1-\eta)n_{it-1}$, and the new matches in the current period, $q_t^f v_{it}$.

To hire workers, each firm creates v_{it} vacancies at fixed sunk cost $x > 0$ measured in terms of the final good and pays real wage w_{it} per employee for supplying h_{it} hours of work. Both w_{it} and h_{it} are determined jointly by workers and the firms in a privately efficient way, through Nash bargaining solution. They are therefore taken as given when maximising profit (Faccini et al., 2013; Ravenna & Walsh, 2012; Trigari, 2006). Also, we assume that each firm faces the demand for its product given by equation (8). Given the price of final good, P_t, and the initial value of employment, the optimization problem of each firm is to choose that paths for variety price, number of vacancies, number of workers and the amount of capital stock, $\{p_{it+s}, v_{it+s}, n_{it+s}, k_{it+s}\}_{s=0}^{\infty}$, to maximise its present discounted value of expected profit given by

$$maxE_t \sum_{s=0}^{\infty} \lambda_{t+s} \left[\frac{p_{it+s}}{P_{t+s}} y_{it+s} - n_{it+s}w_{it+s}h_{it+s} - r_{t+s}k_{it+s} - (1-\zeta_{t+s}^V)xv_{it+s} - \eta n_{it+s}F_{t+s}\right],$$

subject to the demand function (8), the production function (13) and the evolution of employment in (15), where $\lambda_{t+s} = \beta\Lambda_{t+s}/\Lambda_t$ represents the stochastic discount factor described in subsection 3.2.1.

We assume each firm receives a common subsidy ζ_t^V from the government towards its vacancy creation and pays firing costs, $F_t = PC_t + B$, for laying off workers. The latter consists of a procedural cost component paid to the government and the severance component paid to the worker that is laid off. The procedural cost, in turn, is made up of two components: a fixed cost of separation and severance induced cost.[11] Thus, $PC_t = \alpha_t^f + \eta^w B$, where, $\alpha^f > 0$; $0 < \eta^w < 1$. In particular, η^w can be thought as a measure of the strictness of EPL as in Boeri, Conde-Ruiz, and Galasso (2012) or the degree of enforcement of EPL so that $\eta^w = 1$ and $\eta^w = 0$ correspond to the extreme cases of maximum and no strictness in employment protection policies.

Denoting by J_{it} and by mc_{it} the respective Lagrange multipliers associated with the constraints (15) and (13), the first order conditions, evaluated at $s = 0$, are[12]

$$\frac{p_{it}}{P_t} = \frac{\mathcal{E}_t}{\mathcal{E}_t - 1} mc_{it}, \tag{16}$$

$$\frac{(1-\zeta_t^V)x}{q_t^f} = J_{it}, \tag{17}$$

$$J_{it} = mc_{it} z_t \left(\frac{n_{it}h_{it}}{\phi}\right)^{\phi-1} \left(\frac{k_{it}}{1-\phi}\right)^{1-\phi} h_{it} - w_{it}h_{it} - \eta F_t + (1-\eta) E_t \lambda_{t+1} J_{it+1}, \tag{18}$$

$$mc_{it} z_t \left(\frac{n_{it}h_{it}}{\phi}\right)^{\phi} \left(\frac{k_{it}}{1-\phi}\right)^{-\phi} = r_t. \tag{19}$$

In the absence of price setting frictions, equation (16) represents the standard mark-up pricing rule for a monopolist facing a market demand with price elasticity $\mathcal{E}_t$. Thus, the Lagrange multiplier mc_{it} can be interpreted as the firm's real 'overall marginal cost'. Equation (17) shows that a firm posts the optimal number of vacancies v_{it} that equalises the marginal hiring costs with the value of the marginal match. The value of the marginal match is given by (18) and depends on the marginal revenue product per worker, $mc_{it}\phi\, y_{it}/n_{it}$, wage bill per worker, $w_{it}h_{it}$, firing cost, ηF_t, and the continuation value of the job. Equation (19) has the standard implication that capital is employed until the value of its marginal product (the term on the left-hand-side) equalises its real rental rate (the term on the right-hand-side).

Combining equations (17) and (18), we obtain

$$\frac{(1-\zeta_t^V)x}{q_t^f} = \frac{mc_{it}\phi y_{it}}{n_{it}} - w_{it}h_{it} - \eta F_t + (1-\eta) E_t \lambda_{t+1} \frac{(1-\zeta_{t+1}^V)x}{q_{t+1}^f}, \tag{20}$$

which is the condition that characterises job creation decision of each firm. It states that at every point in time a firm expands employment (by creating vacancies) up to a point where the marginal contribution of an additional worker to the firm (right-hand-side) equals the marginal hiring or vacancy creation costs (the left-hand-side).

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[11] See Bentolila and Bertola (1990) and Garibaldi and Violante (1999) for detailed description of a typical firm's firing cost components.

[12] See 3A.3 in Appendix 3 for the derivation.

3.2.3.2 Optimal Wage and Hours Contract

As already noted, we assume that the real wage and hours per worker are determined through Nash bargaining solution. To facilitate these derivations, it is useful to define the marginal value of employment to a worker employed by firm i as [13]

$$W_{it} = (1-\tau_t)w_{it}h_{it} + \zeta_t^w - \left[b_t + \frac{\mathrm{A}(h_{it})}{\Lambda_t}\right] + \eta B$$

$$+(1-\eta)E_t\lambda_{t+1}[1-q_{t+1}^w]W_{it+1}, \tag{21}$$

where $\frac{\mathrm{A}(h_{it})}{\Lambda_t} = \frac{Ah_{it}^{1+\alpha_h}}{\Lambda_t(1+\alpha_h)}$ is a measure of disutility of work. Equation (24) states that a worker's return from employment with firm i is given by the after-tax wage income adjusted to account for: (i) tax subsidy, (ii) the worker's *unemployment value*, which is increasing in the utility of leisure (measured in terms of its consumption value) and unemployment benefits, and – given that the employment is subject to being terminated at a rate η – (iii) a weighted average of the severance compensation and the discounted continuation value of employment with weights η and $(1-\eta)$, respectively.

Let $\Phi \in [0,1]$, denote a worker's relative bargain power. Since J_{it} and W_{it} are respectively the current marginal gains of employment to the firm and the worker, they correspond to their respective match surplus. The Nash solution to the firm-worker bargaining problem are then given by the real wage and hours per worker which maximise the weighted product of both party's respective surpluses, i.e. $J_{it}^{(1-\Phi)}W_{it}^{\Phi}$, subject to (18) and (21). The first order condition with respect to w_{it} yields

$$\Phi(1-\tau_t)J_{it} = (1-\Phi)W_{it}. \tag{22}$$

The above condition (22) gives rise to the following effective surplus sharing relationships

$$W_{it} = \frac{\Phi(1-\tau_t)}{(1-\Phi\tau_t)}(J_{it} + W_{it}) \tag{23}$$

and

$$J_{it} = \frac{(1-\Phi)}{(1-\Phi\tau_t)}(J_{it} + W_{it}), \tag{24}$$

for the worker and the firm, respectively (Pissarides, 2000, p. 210). As can be seen, distortionary tax, τ_t, influences the *division* of the joint match surplus, $S_{it} = J_{it} + W_{it}$. In particular, a ceteris paribus increase in τ_t reduces a worker's and increases a firm's share of the match surplus. However, as discussed later, τ_t reduces the joint surplus of a match and so both firms and workers are worse off.[14]

By substituting equations (18) and (21) into the first order condition (22) and rearranging, we obtain the wage equation

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[13] This is also interpreted as the household's net value of having an additional worker employed at firm i.

[14] See Pissarides (2000) and Vanhala (2006) for a similar effective surplus sharing rule.

$$w_{it}h_{it} = \Phi\left(\frac{mc_t\phi y_{it}}{n_{it}} - \eta\left(\alpha_t^f + \eta^w B\right)\right) + \Phi\left((1-\eta)E_t\lambda_{,t+1}\frac{(1-\zeta_{t+1}^V)x}{q_{t+1}^f}\right)\times$$
$$\left(1-(1-q_{t+1}^w)\frac{(1-\tau_{t+1})}{(1-\tau_t)}\right) + \left(\frac{1-\Phi}{1-\tau_t}\right)\left(b_t + \frac{Ah_{it}^{1+\alpha_h}}{\Lambda_t(1+\alpha_h)} - \zeta_t^w\right) - \frac{(1-\Phi\tau_t)\eta B}{(1-\tau_t)}. \quad (25)$$

In the absence of policy instruments $\left(\alpha_f, \eta^w, B, \tau, \zeta^w, \zeta^V\right) = 0$ the above equation collapses to the standard wage expressions normally found in the literature with DSGE enhanced with search and matching frictions – see Krause and Lubik (2010); Di Pace and Faccini, (2012) and Krause et al. (2008). In general, equation (25) shows that the wage paid to the worker is a weighted average of the match productivity net of the procedural cost of firing, plus the savings from job continuation and the worker's outside option of the worker, adjusted for employment tax subsidy, and severance compensation.

Clearly, equation (25) reveals that $\partial w_{it}/\partial \alpha_t^f < 0$, $\partial w_{it}/\partial B < 0$ and $\partial w_{it}/\partial \zeta_t^w < 0$, all else equal. Intuitively, wages are negotiated such that the costs of severing employment relationships are partly transferred to the workers. The extent to which this occurs entirely depends on the worker's relative bargaining strength Φ. In the extreme case where a firm has no bargaining power ($\Phi = 1$), a worker bears the entire cost of layoff but enjoys the entire value of his/her marginal product. In the other extreme case, when $\Phi = 0$, the worker has no bargaining power and has to accept his reservation wage adjusted for tax subsidy and (expected) severance compensation. Thus, as in the partial equilibrium setting of, e.g., Lazear (1990) and Garibaldi and Violante (2000), whilst the firm bears the entire burden of the procedural cost of laying off a worker, it is able to transfer the entire burden of the tax adjusted severance payment to the worker through wage cuts. An interesting feature is that when none of the agents to the job match has absolute power, i.e., $0 < \Phi < 1$, the presence of distortionary tax can amplify the burden of severance transferred to the worker. To see this, suppose $\tau_{t+1} = \tau_t = 0$, the wage equation (25) collapses to

$$w_{it}h_{it} = \Phi\left(\frac{mc_{it}\phi y_{it}}{n_{it}} - \eta\left(\alpha_t^f + \eta^w B\right) + (1-\eta)E_t\lambda_{t+1}\theta_{t+1}(1-\zeta_{t+1}^V)x\right)$$
$$+(1-\Phi)\left(b_t + \frac{A(h_{it})}{\Lambda_t}\right) - \eta B.$$

From the above, it is evident that regardless of the bargaining strength of agents to a match, the total cost of severance compensation is transferred to the worker via wage reduction. As found in Chapter 2 of this thesis (and also in Garibaldi & Violante, 2000) this amount is then deducted over a period of $1/\eta$, i.e. the average duration of a job match before separation occurs. However, in the presence of tax, i.e. $0 < \tau < 1$, the burden passed on to worker is $\frac{(1-\Phi\tau_t)}{(1-\tau_t)}\eta B$, which exceeds ηB, since as $\frac{(1-\Phi\tau_t)}{(1-\tau_t)} > 1$. In fact, the scale factor, $\frac{(1-\Phi\tau_t)}{(1-\tau_t)}$, is increasing in τ and decreasing in Φ, which suggests that while the impact of severance is amplified by the tax rate, the strengthening of a worker's bargaining power reduces it. As for the implications of a change in the tax rate from one period to the next, a ceteris paribus rise in the future tax rate, $\tau_{t+1} > \tau_t$, raises the current wage and vice versa – as found in Burda and Weder (2016) and Campolmi et al. (2011a). Also, an increase in tax subsidy, ζ^w, reduces labour cost to the firm.

Finally, with efficient Nash bargaining, the condition that determines the optimal hours of work can be obtained by differentiating the product of the joint surplus with respect to h_{it} ,

$$\Phi \frac{\partial W_{it}}{\partial h_{it}} J_{it} + (1-\Phi) \frac{\partial J_{it}}{\partial h_{it}} W_{it} = 0, \tag{26}$$

where $\frac{\partial W_{it}}{\partial h_{it}} = (1-\tau_t) w_{it} - \frac{\mathrm{A}'(h_{it})}{\Lambda_t}$ and $\frac{\partial J_{it}}{\partial h_{it}} = mc_{it} z_t \left(\frac{n_{it}}{\phi}\right)^{\phi-1} \left(\frac{k_{it}}{1-\phi}\right)^{1-\phi} h_{it}^{\phi-1} - w_{it}$. Substituting these partial derivatives into (26), and solving using equation (22), we obtain the condition for optimal hours' contract as follows

$$\frac{A h_{it}^{(1+\alpha_h)}}{(1-\tau_t)\Lambda_t} = \frac{\phi^2 mc_{it} y_{it}}{n_{it}}. \tag{27}$$

Condition (27) implies that agents to a job match bargain hours supply such that its marginal product equals the tax adjusted marginal rate of substitution between consumption and leisure. As pointed out by Trigari (2006), this is the correct measure of worker's input to the firm in the sense of a frictionless labour market rather than the wage rate, since the existence of search and matching frictions make the wage rate unequal to the worker's marginal product.

3.2.4 The Government

We abstract from public debt – in line with Baxter and King, (1993), Burnside et al. (2004) and Angelopoulos, Malley, and Philippopoulos (2012), among others – and assume that the government maintains a balanced budget in each period.[15] The budget constraint of the government, therefore, takes form

$$T_t + \int_0^1 \tau_t w_{it} n_{it} h_{it} di + \int_0^1 \eta n_{it} PC_t di =$$
$$G_t + \int_0^1 (1-n_{it}) b_t di + \int_0^1 \zeta_t^w n_{it} di + \int_0^1 \zeta_t^V x v_{it} di, \tag{28}$$

where the right-hand-side of (28) reflects aggregate government expenditure consisting of spending on consumption goods, unemployment benefits, tax subsidy and job creation subsidy. These expenditures are financed using revenues received from taxing on labour income and the household, the proceeds received from the procedural cost of firing, $PC_t = \left(\alpha_t^f + \eta^w B\right)$. To avoid the distortionary effects of taxes on labour and firms, we follow convention (e.g., Cantore et al., 2014; Monacelli et al. 2010) and allow lump sum tax to adjust to balance the government budget in the baseline analysis.

[15] As argued by these authors abstracting from public debt will not alter the results of the model given that households interpret variations in debts and lump-sum tax in the same way.

3.3 Aggregation and Market Clearing Conditions

In line with the literature, we restrict our attention to an equilibrium where firms behave identically – the symmetric equilibrium. Therefore, the following hold: $P_t = p_t = p_{it} = 1$; $K_t = k_{it}$; $\Pi_t = \pi_{it}$; $V_t = v_{it}$; $N_t = n_{it}$; $h_t = h_{it}$; $w_t = w_{it}$; $mc_t = mc_{it}$. Firms' profit therefore given by

$$\Pi_t = Y_t - [w_t N_t h_t + r_t K_t + (1 - \zeta_t^V) x V_t + \eta N_t F_t]. \tag{29}$$

The equations which determine the aggregate equilibrium values of the endogenous variables for period t are given in Appendix 3 (section 3B).

Combining household's budget constraint, firms' profit and the government budget constraint – respectively given by (2), (28) and (29) – we obtain $C_t + I_t + G_t = Y_t - xv_t$ which represents the national income identity and implies that the final good market clears: the left-hand-side consists of the three sources of demand, and the right-hand-side is the value of output net of what is used in creating the vacancies.

The two equations governing the flows of employment (given by equation (15), which we repeat here) and unemployment are

$$N_t = (1 - \eta) N_{t-1} + M_t, \tag{15}$$

$$U_t = [1 - N_{t-1}] + \eta N_{t-1}. \tag{30}$$

According to (15), aggregate employment at any time *t* consists of the total number of workers whose employment were not severed $(1 - \eta)N_{t-1}$ in the preceding period and the newly-matched workers M_t. Equation (30) shows that aggregate unemployment is given by the number of workers who were not at all unemployed from last period $t - 1$, $[1 - N_{t-1}]$, and those who were employed but lost their job at the end of that period, ηN_{t-1}.

Finally, all exogenous variables and policy instruments are assumed to follow an autoregressive process of order one AR (1):

$$\log l_t = \rho_l \log l_{t-1} + \psi_{lt}; \quad l_t = \mathcal{E}_t, G_t, b_t, \alpha_t^f, \zeta_t^w \text{ and } \zeta_t^V, \tag{31}$$

where $\rho_l \in [0,1]$ is autoregressive parameter measuring the persistence of the respective AR(1) process (31), and ψ_{lt} represents random shock, assumed to be $\sim WN(0, \sigma_l^2)$.

3.4 Model Calibration

We calibrate the model to reflect the structural characteristics of the UK economy with quarterly frequency, using the parameter and steady state values commonly used in the literature.[16] The parameter values used are summarised in Table 3.1.

We set the subjective discount factor, β, to 0.99, consistent with the value widely used in the literature, which implies a steady state quarterly real interest rate of about 4 percent. To obtain an average annual capital depreciation rate of 10 percent, we set the quarterly depreciation

[16] As in Trigari (2006), Krause and Lubik (2007), Krause et al. (2008), Faccini et al. (2013) and many others within this line of literature. Also note that most of the values chosen here are based on studies which focus on the UK economy.

rate of capital $\delta = 0.025$ as in Zanetti (2011a). The actual empirical estimate of the inverse of Frisch elasticity of hours supply, α_h^{-1}, is still contested in the literature. As pointed out by Trigari, (2006, 2009), the micro estimates of α_h^{-1} range from close to 0 to approximately 0.5. In our baseline calibration, we set $\alpha_h = 2$, which corresponds approximately to $\alpha_h^{-1} = 0.5$, consistent with the literature focusing on the UK economy (e.g. Villa & Yang, 2011). The coefficient of relative risk aversion, α_c, is set to 0.9, close to the posterior mean estimate obtained by Faccini et al. (2013). The degree of substitutability between private consumption and public consumption in the household's utility function is set to $\varphi = 0.1$ per quarter, which is consistent with the empirical estimate obtained for the UK by Ahmed (1986). As is common in the literature, we set hours per worker, $\bar{h}$, to 1/3 and allow the measure of disutility of working, A, to be residually determined. The implied value of A from the steady state computation equals approximately 13.0218.

Hall (2005) document that quarterly job separation rate is in the range of 8 and 10 percent in the US. We use the estimate for the UK provided by Hobijn and Şahin (2009) and set the steady state quarterly job separation rate η to 0.0459. This value implies that established job matches last up to 20 quarters (or a period of 5 years), on average. In line with Villa and Yang (2011), we set the value of the elasticity of demand for differentiated goods, $\mathcal{E}$, to 6. This gives a steady state price mark-up over marginal cost of 20 percent, consistent with most studies within this area of research – see, e.g., Campolmi et al. (2011b). The bargaining power of workers is assumed to be symmetric as in Pissarides (2000); therefore, we let $\Phi = 0.5$. Following Pissarides (1998) we set matching elasticity γ to equal Φ in order to satisfy Hosios (1990) search efficiency condition. The benchmark value of the elasticity of output with respect to labour input ϕ is set to 0.69, in the same manner as Faccini et al. (2013).

We define the initial unemployment benefit in terms of the steady state wage bill: $\rho_b = \bar{b}/(1-\tau)\bar{w}\bar{h}$, where ρ_b, set to 0.38 as in Faccini, Millard, and Zanetti (2011), captures replacement rate of unemployment benefits. It is common within DSGE search literature to define the quarterly job filling rate of firms, $\bar{q}^f$, and the level of employment, $\bar{N}$, in order to facilitate the derivation of the steady state values of other labour market variables. Hence, in line with Zanetti (2011a), we set $\bar{q}^f$ and $\bar{N}$ to equal 0.9 and 0.945 respectively. The size of the labour force is normalised to one. Thus, the value of $\bar{N}$ implies a steady state unemployment rate of 0.055 and aggregate number of job searchers of $\bar{U} = 1 - (1-\eta)\bar{N} = 0.09838$. Given steady state employment rate and job destruction rate above, the aggregate quarterly number of new matches in the economy is $M(\bar{U},\bar{V}) = \eta\bar{N} = 0.04338$, while the aggregate number of vacancies created is given by $\bar{V} = M(\bar{U},\bar{V})/\bar{q}^f = 0.0482$. The steady state solutions for job finding rate, $\bar{q}^w$, and the degree of market tightness, $\bar{\theta}$, are respectively given by $\bar{q}^w = M(\bar{U},\bar{V})/\bar{U} = 0.44092$ and $\bar{\theta} = \bar{V}/\bar{U} = 0.48991$. The measure of match efficiency is therefore obtained as $\chi = \frac{M(\bar{U},\bar{V})}{\bar{U}^{\gamma}\bar{V}^{1-\gamma}} = 0.62994$. Vacancy creation cost, x, is determined residually from the steady state calculation.

Regarding policy parameters, we calibrate the steady state share of government consumption spending in output, $\bar{G}/\bar{Y}$, to match the historical average of 0.2199 for the UK between the period 1980: Q1 and 2013: Q1. The initial values of recruitment and tax subsidies, ζ^V and ζ^w, and the measure of EPL strictness, η^w, are set to zero. Zanetti (2011a) calibrated the firing cost of a firm to 0.3, which corresponds to the procedural cost in this study given that the author excludes the severance transfer component. As pointed out by Garibaldi and Violante (2000), however, the severance transfer component of firing cost constitutes about 90 percent of total firing costs in the UK. For the purpose of our study we assume that two-third of the total firing cost represents pure transfer to each worker, B. Thus, using the fact that $B = (2/3)\bar{F}$ and $\overline{PC} = (\bar{\alpha}^f + \eta^w B) = 0.3$, we have a total cost of firing which equals $\bar{F} = \bar{\alpha}^f + (1 + \eta^w)B = 0.9$. In line with Angelopoulos et al. (2012) we set the benchmark value of labour tax rate $\tau = 0.27$, and allow lump-sum taxes to adjust to satisfy the differences in government expenditure and revenue received (as in Harrison & Oomen, 2010; Shi & Wen, 1999). Also, in line with the literature, the steady state aggregate output Y is normalised to one, while allowing the measure of total factor productivity z to adjust to target this value. The persistence parameter for all exogenous variables/policy instruments and the standard deviation of shocks are respectively set to 0.90 and 0.01 in all cases to facilitate comparison of the effects of shocks on the economy.

Table 3.2 in Appendix 3 summarises data averages of key economic indicators compared with the steady state solutions of the model. As can be observed these solutions very closely matches some of the key structural characteristics of the UK economy.

3.5 The Match Surplus

To help understand how labour market institutions and policies affect the dynamics of labour market discussed in the next section, it is useful to briefly discuss the role of match surplus, which have been found to be crucial in determining the response of labour market variables to shocks (Hornstein et al., 2005; Shimer, 2005). Using equations (18) and (21) the expression for the steady state match surplus can be written as

$$\bar{S} = \frac{\overline{mc}\phi\bar{Y}}{\bar{N}} - \bar{\tau}\bar{w}\bar{h} - \eta(\bar{\alpha}^f + \eta^w B) - \left(\bar{b} + \frac{A\bar{h}^{1+\alpha_h}}{(1+\alpha_h)\bar{\Lambda}} - \zeta^w\right) + \frac{(1-\bar{\zeta}^V)x(1-\eta)\beta\bar{\theta}^\gamma}{(1-\Phi)\chi}\left((1-\Phi\bar{\tau}) - \Phi(1-\bar{\tau})\chi\bar{\theta}^{1-\gamma}\right). \qquad (32)$$

The above equation (32) shows that labour market institutions have clear implications for the match surplus. For a given value of η, an increase in either the fixed separation cost, $\bar{\alpha}^f$, or severance, B, reduce the size of the match surplus – with the effects of severance increasing in the strictness of EPL, η^w. Recall that a firm's effective share of the sum of the match surplus is given by $J = \frac{(1-\Phi)}{(1-\Phi\tau)}S$. It follows that the value of a given job match to the firm is also reduced by an increase either in the fixed separation cost or severance induced cost – caused by an increase in η^w or B, or both. Given the equality condition for job creation (equation (20)), a lower J must, therefore, be met by a reduction in the number of vacancies. More precisely, suppose we let $\zeta^V = \zeta^w = \tau = 0$, it can be shown that the value of a job match to the firm, J, is reduced by an amount $\eta(\bar{\alpha}^f + \eta^w B)$. Higher values of unemployment benefits (b) and distortionary tax (τ) also reduce the match surplus through their impact on workers' valuation of unemployment (as we will explain later) and so have a similar qualitative effect on job creation.

3.6 Steady State (Long-run) Comparative Statics

Here, we explore the steady state properties of the model in order to understand the long-run effects of: (i) fixed separation cost, $\bar{\alpha}^f$; (ii) severance compensation, B; (iii) recruitment and tax subsidies, ζ^V and ζ^w; (iv) distortionary labour tax, τ; (v) the measure of the degree of substitutability between private and public consumption, φ; (vi) government consumption spending, G; and (vii) unemployment benefits, b. The results from this exercise will shed light on the effects of, especially, labour market policies/institutions on the transmission of shocks discussed in the next section.

Fixed separation cost: Consider a sudden increase in fixed separation cost, α_f. By raising the procedural cost of separation, a higher α_f reduces the size of the match surplus as well as the value of a filled job. This reduction weakens the incentives for vacancy creation, resulting in lower market tightness, θ. A lower θ triggers decline in job finding rate, causing extensive margin employment to fall and aggregate unemployment to rise. The duration of unemployment spell measured by $\bar{q}^{w^{-1}}$ also increases. Consequently, labour income falls, leading to a tightening of the household budget, as evident by the drop in household disposable income (HDI), and causing consumption and capital accumulation to fall. Given the decrease in job creation, and thus in extensive margin employment, firms meet production requirements using increased hours supply. The rise in hours per worker is however not sufficient to boost productivity, and so $\bar{Y}$ drops, further reducing HDI due to lower returns to capital and profit remittances. Also, despite the increase in unemployment benefit income resulting from higher unemployment, the HDI falls due to the negative effects of wage, capital and profit income.

Severance compensation: An increase in severance compensation, in the absence of any strict enforcement in EPL, $\eta^w = 0$, has no adverse effect on job creation decision, which is the usual result in the search literature as predicted by Lazear (1990). As recently emphasised by Parsons (2013), severance has little or no impact in economies without strict EPL enforcement. In this model, when $\eta^w = 0$, severance pay could even lead to higher job creation. This is because firms can, intuitively, take advantage of no strictness in employment protection regulation to deduct the severance amount from the negotiated real wage. To see this, consider the steady state surplus equation (32). For a given real wage, an increase in severance leaves the match surplus unaffected if $\eta^w = 0$. However, since firms are able to pass the burden of severance – which is further amplified by the presence of distortionary tax as shown in equation

(25) – to the workers, the resulting lower real wage will increase the surplus, thereby incentivising firms to create more vacancies. By contrast, when firms are faced with strict EPL enforcement, $\eta^w > 0$, the match surplus and the value of a job match become smaller as severance increases. As shown in column (5) of Table 3.3 in Appendix 3, the reduction in the value of a job causes vacancy creation and the degree of market tightness to fall as well, resulting in a lower job finding rate and higher unemployment. Consequently, output, consumption and investment all reduce.

Subsidies: Columns (6) and (7) of Table 3.3 respectively show the long-run effects of recruitment and employment tax subsidies, ζ^V and ζ^w. Whilst both subsidies have a similar qualitative effect on all the variables, their effects on the real wage and match surplus differ. The immediate impact of an increase in recruitment subsidy, ζ^V, is to reduce the marginal cost of vacancy creation relative to the value of a filled job. This implies vacancies must increase in order to restore the job creation condition, thus resulting in a higher market tightness. The increase in market tightness lowers firms' vacancy filling rate. Therefore, for a given match that survives job separation at a rate $(1-\eta)$, an employed worker is compensated, since the recruitment need of the firm is reduced (Pissarides, 2000). This, in turn, leads to a higher real wage and a lower match surplus. Despite the increase in the real wage, the reduced cost associated with vacancy creation subsidy raises employment via a higher job finding rate. By contrast, the employment tax subsidy, ζ^w, directly reduces the real wage cost of firms and, in turn, boosts match surplus, inducing more hiring and lower unemployment. In both cases, productivity rises due to higher employment, resulting in higher labour, capital and profit income to the household, which consequently leads to increases in consumption and investment.

Distortionary tax: Compared to the fixed cost of separation and severance compensation, the impact of an increase in distortionary tax, τ, on the economy is more substantial. A higher τ magnifies workers' outside option (unemployment value) and leads to a higher real wage. Consequently, the size of match surplus and the value of a job match fall, discouraging firms from engaging in vacancy creation. The decrease in vacancy creation causes market tightness and job finding rate to fall; thus, unemployment rises while employment at extensive margin reduces. Employment at intensive margin (the hours per worker) also drops since the distortionary tax raises the disutility of work (equation (27)). Hence, even though the real wage rises due to a higher outside option, the reduction in hours per worker and number of employees reduce labour income. Thus, accompanied by the decreases in profit and capital income, the reduction in labour income leads to lower HDI, causing consumption and investment to fall.

Government consumption expenditure: An increase in $\bar{G}$ raises aggregate demand, creating profit-making opportunities for firms and causing the match surplus to rise. The utilisation of factor inputs, labour and capital, consequently shoots up, causing vacancy creation and the overall market condition, as captured by the increase in the degree of market tightness, to rise. Both job finding rate and employment at extensive margin rise as well, while aggregate unemployment falls. As we would expect, households cut down on consumption due to negative wealth effect (fall in HDI) introduced by an increase in tax obligation required to balance government budget. Moreover, because government consumption is utility-enhancing, it encourages further cut in the household's consumption, who, instead, channel their resources towards investment to attract higher returns associated with the increase in government consumption demand.

For a higher φ value, a given government expenditure yields more utility to the household and causes a larger decline in the marginal utility of consumption, $\bar{\Lambda}$. The fall in $\bar{\Lambda}$ consequently drives up worker's valuation of unemployment and, in turn, reduces the surplus of a job match, leading to lower vacancy creation and higher unemployment. Employment at intensive margin falls as well due to an increase in the consumption value of the disutility of supplying work hours. The overall effect of a higher φ is thus to cause aggregate output in the economy to fall; even when government expenditure rises, its impact on output and employment are lower (Kwan, 2007).

Unemployment benefits: As with the case of the distortionary tax, the impact of higher unemployment benefits on the economy is also substantial compared to those caused by fixed separation cost and severance compensation. A comparison of benchmark results and those reported in column (3) of Table 3.3 reveals that an increase in unemployment benefit, b, reduces vacancies, the job finding rate and the number of job matches, and results in higher unemployment. The intuition is that a higher b raises workers' outside option and leads to a higher wage, which, in turn, reduces match surplus and the incentive for vacancy creation. We consider scenarios where the government can provide more generous benefit insurance for the unemployed and at the same time avail ALMPs to encourage hiring. Columns (12) and (13) in Table 3.3 shows the results of two scenarios with a joint increase in b and ζ^V, and b and ζ^w. As suggested by these results, the effects of a higher unemployment benefit on job creation are lower when accompanied by ALMPs compared to when it is implemented in isolation. In particular, it is possible to offset the effects of higher benefits on job creation if accompanied by employment tax subsidy, ζ^w, as revealed in column (13).

3.7 Dynamic Analysis

In order to solve the dynamic version of the model, we log-linearise the model about the non-stochastic steady state using first order Taylor series expansion. The linearised version is then solved using Dynare (Adjemian et al., 2014).[17] The complete log-linearised model is given in

[17] The complexity of DSGE models makes it difficult to obtain a close-form solution. Thus, to reduce computational burden, researchers often resort to *linear approximations* of the nonlinear equations characterising the equilibrium, which can then be solved using various solution techniques for linear difference equations under rational expectations (e.g., as discussed by Aruba et al., 2006; Flotho, 2009; Negro & Schorfhiede, 2013). With the

Appendix 3, where "hat" is used to denote the percentage deviation of a variable (x_t) from its steady state $(\bar{x})$, i.e. $\hat{x}_t = \log\left(\frac{x_t}{\bar{x}}\right) = \log\left(1 + \frac{x_t - \bar{x}}{\bar{x}}\right) \approx \log 1 + \frac{1}{\bar{x}}(x_t - \bar{x}) = \frac{x_t - \bar{x}}{\bar{x}}$. [18] Thus, except otherwise stated, the impulse responses of endogenous variables are interpreted as percentage deviation from the steady state. In what follows, we discuss the dynamic results of the model, starting with the baseline case.

3.7.1 Benchmark Results

Figures 3.1, 3.2 and 3.3 in Appendix 3 plot the baseline impulse response functions (IRFs) – based on benchmark calibration described in Section 3.4 – to a positive one standard deviation shock to TFP, government consumption and unemployment insurance spending, i.e., z_t, G_t and b_t. As shown in Figure 3.1, the TFP shock produces positive impact responses on the selected variables with the exception of unemployment, which falls as hiring activities rises. On impact, productivity per factor input rises, leading to a significant increase in match surplus. In response, vacancy creation increases, accompanied by a strong tightening in the labour market and an increase in job finding rate. The increase in job finding rate raises employment and decreases in unemployment. Employment and hours worked per worker respond differently to TFP shock (Krause & Lubik, 2010). Intuitively, given that hours per worker is driven by the marginal rate of substitution between consumption and leisure, as more people become employed, the hours spent working reduces. This is because the level of consumption rises due to increased wage, capital and profit income, which leads to higher household disposable income.

Figure 3.2 displays the impulse response to a positive government consumption shock, G_t. By raising aggregate demand, an increase in G_t leads to a rise in match surplus, on impact. Therefore, firms create more vacancies, prompting increases in the market tightness, job finding rate, aggregate new matches and the number of employment. The real wage, however, falls. As explained above, the reason is that, by raising marginal utility, an increase in G_t reduces the consumption value of the disutility of work, which in turn lowers the value of unemployment and, consequently, the real wage, consistent with Monacelli et al. (2010). Also consistent with the literature, the positive government consumption shock crowds out private consumption, due

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advancement in computing power, software such as Dynare and Perturbation AIM are now available for solving DSGE models. Dynare has been used, for instance, by Cahuc and Barbanchon (2010), Gorodnichenko and Weber (2016), Mandelman and Zanetti (2008), Sophocles, Plagborg-Møller, and Stock (2014), and Weber (2015) in handling various economic models, including DSGE. In general, it is a toolbox for Matlab developed by Adjemian et al. (2014) that allows researchers to write the model in its original or linearised form; further information about Dynare can be found at http://www.dynare.org/. A key limitation of this software, which does not apply to the model, is that it can only find solution up to third order approximation (Fernandez-Villaverde et al., 2016). Pfeifer (2014, 2015) provides extensive coverage of ways to specify DSGE models and graphs in Dynare. The Perturbation AIM, developed by Swanson, Anderson, and Levin (2006), is implementable in Mathematica; see, http://www.ericswanson.us/perturbation.html for more information.

[18] Steady state solutions are computed using Maple and Matlab. All the codes are available upon request.

to negative wealth effect induced by an increase in tax obligation. Investment also decreases minimally, causing capital accumulation to fall.

Figure 3.3 shows that a shock to unemployment insurance benefit reduces the size of match surplus by raising workers' value of unemployment, thus leading to a rise in the real wage on impact. Consequently, the gains from posting new vacancies shrink considerably, forcing firms to reduce recruitment activities. This, in turn, leads to the deterioration of market tightness, driving down both job finding rate and employment. Those in employment supply more hours per worker as employment shrinks. However, the rise in hours per worker is not sufficient to sustain production, and so output drops, further leading to less demand for labour and capital. The decline in the economy's output causes profit to fall and, together with the fall in labour and capital income, results in lower private consumption as well as investment.

3.7.2 Labour Market Institutions and Shock Propagation

We now investigate the implications of labour market institutions and policies (highlighted in the previous section) on the transmission of shocks. In particular, we focus on the effects of (i) fixed separation cost; (ii) severance compensation; (iii) unemployment benefit and (iv) distortionary tax. Figures 3.4 and 3.5 display the IRFs to positive TFP and government consumption shocks, respectively. We focus on these two shocks, and to facilitate comparison, the economy is subjected to shocks of equal size as in the baseline case above.

Obviously, changes in individual labour market institutions do not alter the qualitative response of the plotted variables to shocks, but affects their magnitude and persistence of responses.[19] The magnitude of response of each variable – particularly those of the labour market – depend crucially on the way each policy affects the surplus of a job match. The smaller the size of the match surplus, as a result of a policy change, the larger is the effect of shock on the adjustment path of these variables. The intuition is that when the match surplus is initially small, a positive shock which enhances productivity generates a larger percentage increase in the value of a job match. All else equal, this implies that vacancies must rise until the value of a match equals the cost of creating the vacancy. Hence, shocks are transmitted through rapid adjustment in the number of vacancies unto employment and, consequently, output. As shown by Hagedorn and Manovskii (2008), Hornstein et al. (2005) and Shimer (2005) within a partial equilibrium framework, even a *small* shock can result in large amplification in vacancies and employment when the size of equilibrium match surplus is small.

As suggested by the steady state results presented in the previous section, higher α_f, ηB, b and τ result in considerable decrease in the match surplus. Thus, as we would expect, the dynamic adjustment of the match surplus following TFP and government spending shocks under different labour market regimes are much larger compared to the baseline responses. For the TFP shock, the response of employment is enhanced as a result of firms' adjustments through higher

[19] These sensitivity analyses confirms the robustness of our numerical solution.

vacancy creation. The peak responses and persistence are much larger than the baseline case. The final impact of the shock on output depends on the strength of the responses of hours per worker and capital. In all instances after regime change, the response of hours per worker is weakened as the magnitude of employment rises. However, given the increased number of workers in employment, the impulse of aggregate hours supplied by workers (i.e. the product of the number of workers and the hours supplied by each) remains resilient. Thus, together with the stronger response in capital (though not quantitatively large), the impulse of output is slightly amplified. The effects of fixed separation costs and severance compensation on the transmission of TFP shock are, however, quantitatively small compared to the effects of benefit insurance and distortionary tax. This follows from the fact that they do not significantly alter the steady state match surplus and household disposable income compared to the effects of benefit insurance and distortionary tax.

The case of government consumption shock (displayed in Figures 3.5) appears to be more significant quantitatively. The impact and peak effects of employment, hours per worker and output are amplified under all four scenarios, as are the persistence of responses. Higher steady state distortionary tax and unemployment benefit affect these responses in a more profound way – the former, primarily through its effect on individual work hours. A higher distortionary tax reduces the steady state HDI, making the household more sensitive to further increase in government consumption spending, especially since such spending is associated with additional decrease in HDI via tax increase. Therefore, consumption and capital accumulation fall much more on impact compared to the benchmark case. The additional weakening in consumption therefore strengthens the response of hours per worker, which, in turn, reinforces the response of output. A permanent rise in unemployment insurance benefit, also has a significant negative effect on the HDI and the match surplus as shown in Table 3.3. Thus, as in the case of distortionary tax, a smaller HDI responds more to shocks, leading to a larger drop in consumption and an increase in hours per worker. The response of vacancies, and in turn employment, is also amplified due to increased value of match surplus following the government spending shock. The implications of changes in fixed separation cost and severance compensation on the transmission of government consumption shock are similar to that of benefit insurance. But unlike unemployment benefit, their effects are also relatively small as in the case of TFP shock. A clear implication of our findings is that whilst the magnitude of response of vacancies and employment depend on the initial value of match, the magnitude of response of hours per worker to a given shock depends on the initial disposable income of the household.

3.7.3 The Effects of Subsidies on the Labour Market

Recent empirical evidence suggests that policies targeted at the labour market are more effective in stimulating job recovery compared to the traditional government consumption spending (see e.g., Tcherneva, 2011). In reality, however, labour market-oriented fiscal spending takes different forms.[20] Here we examine the short run dynamic effects of the two forms (tax and recruitment subsidies) considered in this chapter. (In subsection 3.7.6 below, we show how the multiplier effects of these subsidies compare those of fiscal consumption spending.) In Figure 3.7, we report the IRFs of selected variables to a positive one percent standard deviation shock to recruitment and tax subsidies; the solid and dash-dot lines represent the impulses resulting from the respective shocks. As illustrated by the figure, both subsidies have the same qualitative impact on vacancies, employment and hours worked. Also, in both cases, consumption, capital and output all increase. The mechanisms remain the same as previously explained. On impact, by directly reducing job creation cost, a higher recruitment subsidy raises vacancy creation rate. Consequently, the market tightness and job finding rate rise, positively impacting the aggregate number of new matches and employment. Tax subsidy also enhances vacancy creation on impact, but in contrast to the recruitment subsidy, it leads to a decrease in the real wage as against directly reducing vacancy creation cost. The fall in real wage, thus, allows match surplus to rise, which then induces higher recruitment activities.

Quantitatively, the effects of both subsidies differ in the short run. A one percent standard deviation shock to recruitment subsidy generates a stronger effect on variables compared to a shock of equal size to tax subsidy. The peak response of vacancies is 0.2 percent above the steady state level, while that of employment is 0.008 percent. In contrast, vacancies (employment) increase (reduce) by 0.16 (0.0052) percent in response to a positive shock to tax subsidy of equal size. This suggests that recruitment subsidies could be more effective in fostering employment in the short run. This result is surprising considering that the real wage rises under recruitment subsidy, whereas falls under tax subsidy, due to the reason explained in Section 3.6.[21] The fact that recruitment subsidy can be an effective policy instrument for job creation has been documented by Campolmi et al. (2011b) and Kato and Miyamoto (2015). Kato and Miyamoto studied the short-run effects of vacancy creation and employment subsidies in a DSGE model with search frictions. The difference between the subsidies considered by the authors and ours is that, in their paper, both subsidies are given to the firms.

3.7.4 Alternative Government Expenditure Financing

The results from fiscal stimulus policies considered above show positive effects on employment and on output when financed by lump-sum taxes (Faia, Lechthaler, & Merkl, 2013; Monacelli et al. 2010). In reality, however, an increase in government expenditures can be offset, fully or partly, by revenues generated through various financing schemes (Baxter & King, 1993; Campolmi et al., 2011b). Here, we examine the impact of a fully distortionary tax-financed

[20] See Martin (2014) for discussion on the types of ALMPs and their effectiveness.

[21] Note that job creation cost can be likened to the cost of setting up a job/business. Intuitively, the higher ease of setting of business within an economy, the more vacancies will become available. Moreover, since firms do not have to keep vacancies for long –thus loosing gains from production – they may be willing to pay higher salaries to continuing workers to in order to maintain productivity level.

government fiscal spending. Figures 3.7, 3.8 and 3.9 respectively display the responses of selected variables to an increase in government consumption expenditure, recruitment and employment tax subsidies under two financing options: lump-sum vs distortionary tax. Clearly, compared to lump-sum financing, a distortionary tax-financed government consumption expansion leads to a decrease in match surplus, reducing the incentive for vacancy creation. The reason is that the corresponding increase in the distortionary tax – associated with the government's consumption expansion – generates higher labour cost to the firms via an increase in the disutility of work. Accordingly, the real wage rises, forcing firms to cut down on vacancy creation. As employment reduces, the aggregate labour income to the household drops also. The tightening in the household budget leads to substantial reduction in both private consumption and investment, further compounding the contractionary effects of distortionary tax-financing.

Figure 3.8 shows that the responses of variables to a distortionary tax-financed recruitment subsidy differs considerably from the earlier case. In particular, the rise in recruitment subsidy produces a strong and positive impact on vacancy creation and employment, despite being financed by distortionary tax. Output, private consumption and capital also rise. The mechanism through which this occurs remain as previously explained. However, and surprisingly, rather than increase tax obligations, recruitment subsidy reduces it. As explained by Campolmi et al. (2011a), policies such as recruitment subsidy are likely to become *self-financing*, which can serve as an incentive for the government to introduce a temporal decrease in distortionary tax. This reduction, in turn, puts less pressure on HDI, which further stimulates consumption and investment in capital. Higher consumption boosts the continuation value of vacancies and aggregate demand, spurring firms to increase hiring activities and leading to overall improvement in the labour market condition.

Tax subsidy – in Figure 3.9 – financed by distortionary tax has a less adverse effect on employment, compared to government consumption spending under a similar financing option. In fact, it generates positive employment at the extensive margin, on impact, due to increased number of vacancies. A distortionary tax-financed tax subsidy has two opposing effects on the real wage: while an increase in tax subsidy lowers the real wage, the accompanying increase in distortionary tax raises it. The impact of this on the real wage thus depends on which effect dominates. As shown in Figure 3.9, the decrease in the real wage suggests that the effect of tax subsidy dominates. There is, thus, a relatively small incentive to post vacancies. However, given that a higher distortionary tax reduces the incentive to supply work hours, the hours per worker reduces significantly; thus, even though the actual number of workers employed rises, on impact, aggregate hours supply drops. Consumption and capital accumulation also fall due to lower household income resulting from reduced labour and capital income as well as profits.

3.7.5 Utility-Enhancing Government Consumption

In section 3.6 we introduced a higher the degree of substitutability between private and public consumption, φ, and then examined the implications on the economy. We show, numerically, that for a given level of government consumption expenditure, by driving up the value of non-work activities, a higher φ makes job creation costlier and results in lower employment. Output also declines due to further cut in aggregate demand. Here we investigate how the propagation of government consumption spending shock to the rest of the economy is shaped by a higher value of φ and then compare the results to those obtained from the benchmark economy.

In Figure 3.10 we present the impulse responses of selected variables to one percent standard deviation shock to government consumption under two different values of φ: the solid lines represent the benchmark case with $\varphi = 0.1$, while the dash-dot lines plot the case with $\varphi = 0.3$. Clearly – for a plausible parameter range – the qualitative impact of a shock to government consumption spending remains the same for all the plotted variables, expect for scaling. Following an increase in φ, the response of private consumption to an expansionary demand expenditure drops further below the benchmark level (almost by 5 percentage points). In line with Kwan (2007), this result shows that the crowding out effect on private consumption is larger the higher is the degree of substitutability. The intuition is that when public consumption is associated with a higher weight in private utility, the effect of an increase in the latter on aggregate demand *will be offset by a corresponding decrease in private consumption.* This implies that aggregate demand could *potentially* remain unchanged or even reduce as government's consumption expenditure increases, depending on the degree of substitutability. In the case where both consumptions are complements ($\varphi < 0$), an increase in public consumption with will result in a higher aggregate demand in the sense that private expenditure on consumption will also increase (Esteve & Sanchis-Llopis, 2005; Kwan, 2007).[22]

Turning to the effect on the labour market. Since the response of consumption weakens further with a higher φ, the incentive to create vacancies reduces due to the stochastic discount factor and aggregate demand effects – similar to the case described by Campolmi et al. (2011a). Although the household tend to reallocate resources towards capital accumulation, this is not sufficient to mitigate output contraction; therefore, there is a dampening effect on output. Given that vacancies reduce, the responses of market tightness, job finding rate and employment weaken also.

3.7.6 The Multipliers Effects

A recent trend in the literature involves evaluating the effectiveness of fiscal interventions in terms of their multiplier effects (Campolmi et al., 2011a; Faia et al., 2013; Monacelli et al., 2010). In this section, we concentrate on how various labour market policies, government's fiscal offsetting instrument and the degree of substitutability drive the sizes of employment and output multipliers. Following Faia et al., we evaluate fiscal multipliers using their net present values

[22] We, however, do not consider complementarity between private and public consumption. As suggested in Molana and Zhang (2001), $\varphi < 0$ implies that government consumption expenditure is *bad* since it produces negative marginal utility to the household, which may not be consistent.

which are computed as follows:

$$FMult_{t,t+s} = \frac{\sum_{i=1}^{s} \beta^{i-1}(\Xi_{t+i} - \bar{\Xi})}{\sum_{i=1}^{s} \beta^{i-1}(\Theta_{t+i} - \bar{\Theta})}, \tag{33}$$

where $\Xi = Y$ for output multiplier, and $\Xi = N$ for employment multiplier. Θ_t captures the cost associated with a given fiscal instrument at date t, and in the case of pure government consumption spending corresponds to G_t. When considering the fiscal costs associated with tax and recruitment subsidies, we let Θ_t be equal to $\zeta_t^w \bar{N}$ and $\zeta_t^V x \bar{V}$ respectively (see, Campolmi et al., 2011a; Kato & Miyamoto, 2015). Table 3.4 in Appendix 3 summarises the computed multipliers under different time horizons after each shock. Figures 3.11 and 3.12 further display employment and output multipliers, over a 100 quarter horizon, comparing lump-sum and distortionary taxe-financing options.

Apparently, recruitment subsidy turns out to produce substantial employment and output multipliers much larger than one, even when financed by distortionary tax. The intuition for these results is the same as explained in Section 3.7.4. In particular, by inducing a *temporary* decrease in distortionary tax, recruitment subsidy has a more expansionary effect on employment and output level, thus resulting in large multiplier effects. By contrast, the resultant multipliers effects of both government consumption expansion and tax subsidy are quantitatively small, largely below one. The small quantitative effects observed in the former is broadly consistent with the current debates about the ability of DSGE models with search and matching frictions to generate empirically estimated size of fiscal consumption expenditure multiplier (Campolmi et al., 2011a; Cantore et al., 2014; Monacelli et al., 2010). Campolmi et al. (2011b) show that government consumption spending can potentially result in a negative employment multiplier effect when financed by lump-sum tax (due to the crowing out effect on private consumption), which is the case with ours when the offsetting fiscal instrument is the distortionary tax. Additionally, as suggested by the results, an increase in the degree of substitutability between private and public consumption also has a depressive effect on both employment and output multipliers, confirming the empirical evidence documented by Kwan (2007).

The effects of labour market institutions on the fiscal multipliers are also reported in Table 3.4. As with their impact on the transmission of shocks discussed in subsection 3.7.2, fixed firing and severance induced costs do not have substantial impact on government consumption spending and tax subsidy multipliers. They do, however, markedly amplify the multiplier effects of recruitment subsidy. Again, these impacts are more pronounced in the cases of higher steady state distortionary tax and unemployment benefits. The implications of the latter on the effectiveness of fiscal policies (especially demand stimulus) is somewhat controversial in the literature. Monacelli et al. (2010) show that a higher unemployment benefit dampens the multiplier effect of government consumption on unemployment and output. By contrast, Kato and Miyamoto (2013) show that it amplifies employment multipliers, consistent with our findings. A similar result is reported by Mayer et al. (2010) who examined the unemployment effect of government demand stimulus.

In sum, although the effects of labour market institutions on the fiscal multipliers remain qualitatively the same, the quantitative differences that we observe imply that in general labour market rigidities are likely to enhance the multiplier effects of fiscal stimulus policies. In addition, compared to other forms of fiscal stimuli considered in this study, our results consistently demonstrate that only recruitment subsidy can generate positive output and employment multipliers that are above one, even in the presence of labour market rigidities and regardless of the financing option

3.8 Conclusion

The last economic crisis drew significant attention in the literature due to the extensive use of fiscal policy measures to stimulate output and employment across the globe. At the same time, labour market reforms were implemented in many countries. This chapter developed a closed economy dynamic stochastic general equilibrium model with search and matching frictions to study the labour market effects of fiscal stimulus policies and the role of labour market institutions in shaping the transmission mechanisms of these policies.

We show that more rigid labour market institutions, captured by higher fixed firing cost, severance compensation, distortionary tax and unemployment insurance benefit, stifle economic activities and reduce employment. On the contrary, active labour market policies in the form of tax and recruitment subsidies, and government consumption demand all boost economic activities and employment.

Our model indicates that the effectiveness of fiscal policies depends on the degree of substitutability between private and public consumption and labour market rigidity. In particular, we find that a higher degree of substitutability reduces the effectiveness of government consumption spending on aggregate demand and job creation. This is because, by raising private utility, households spend less on consumption as government demand rises; thus, reducing its output and employment effects. Furthermore, our model predicts that, by shrinking the size of match surplus as well the household disposal income in the long-run, rigid labour market institutions make firms and the household more sensitive to government consumption expenditure shock. This, in turn, enhances the effects of the shock on vacancy creation, employment and hours supply. The influence of fixed firing tax and severance compensation in driving this transmission process is, however, quantitatively small compared to unemployment benefits insurance and distortionary labour tax. Finally, our model suggests that labour market-oriented fiscal stimulus policies will be more effective in fostering employment in the presence of rigid labour market. In particular, our results consistently show that only recruitment subsidy can generate positive output and employment multipliers that are above one, even in the presence of labour market rigidities and regardless of the financing option.

As recently suggested in the literature, the functioning of the labour market as a key determinant of the dynamics of unemployment depends not only on the institutional settings of the market but also on a complex interaction between the degree of economic openness and these institutions. In the next chapter, we aim to extend the closed-economy analysis developed in this chapter to an open-economy setting in order to study how economic openness to international trade and capital mobility, as well as their interactions with labour market drive the dynamics of unemployment. This has become important due to the growing concerns that the links (both in trade and capital flow) between countries – globalisation – can serve as an important channel through which economic crisis can be propagated (see Rodrik, 1998). In addition, the recent reforms of labour market institutions towards a flexicurity system – advocated by the European Commission – among the EU member states have been justified by the challenges posed by globalisation (Eurofound, 2007; European Commission, 2010).

Appendix 3

3A Mathematical Derivations

3A.1 Household's Optimisation Problem

The present discounted lifetime utility of the household is given by

$$E_t \sum_{s=0}^{\infty} \beta^s \left[\frac{(C_{t+s}^e)^{1-\alpha_c}}{1-\alpha_c} - A \frac{n_{t+s}\, h_{t+s}^{1+\alpha_e}}{1+\alpha_e} \right], \tag{A1}$$

where $C_{t+s}^e = C_{t+s} + \varphi G_{t+s}$, subject to the budget constrain,

$$C_{t+s} + I_{t+s} + T_{t+s} = \int_0^1 n_{it+s}(1-\tau_{t+s}) w_{it+s} h_{it+s} di$$
$$+(1-n_{t+s}) b_{t+s} + \eta n_{t+s} B + n_{t+s} \zeta_{t+s}^w + r_{t+s} K_{t+s} + \Pi_{t+s}, \tag{A2}$$

and capital accumulation equation

$$K_{t+s+1} = I_{t+s} + (1-\delta) K_{t+s}. \tag{A3}$$

The household maximises (A1) subject to (A2) and (A3). Following Chow (1992, 1993, 1997) and the usual practice in the literature, we can write the Lagrangian of the household optimisation problem as

$$L_H = E_t \sum_{s=0}^{\infty} \beta^s \left(\left\{ \frac{(C_{t+s} + \varphi G_{t+s})^{1-\alpha_c}}{1-\alpha_c} - A \frac{n_{t+s}\, h_{t+s}^{1+\alpha_e}}{1+\alpha_e} \right\} \right.$$
$$\left. + \Lambda_{t+s} \left\{ \begin{matrix} n_{t+s}(1-\tau_{t+s}) w_{t+s} h_{t+s} + (1-n_{t+s}) b + n_{t+s} \eta B + \zeta_{t+s}^w n_{t+s} \\ +r_{t+s} K_{t+s} + \Pi_{t+s} - C_{t+s} - K_{t+s+1} + (1-\delta) K_{t+s} - T_{t+s} \end{matrix} \right\} \right).$$

The first order conditions with respect to $\{ C_{t+s}\}$ and $\{ K_{t+s+1}\}$ are given by[23]

$$\frac{\partial L_H}{\partial C_{t+s}}: \quad E_t[\beta^s (C_{t+s} + \varphi G_{t+s})^{-\alpha_c} - \Lambda_{t+s}] = 0\,; \;\; s \geq 0, \tag{A4}$$

$$\frac{\partial L_H}{\partial K_{t+s+1}}: \quad E_t[\beta^{s+1} \Lambda_{t+s+1}(1 + r_{t+s+1} - \delta) - \beta^s \Lambda_{t+s}] = 0;\; s \geq 0. \tag{A5}$$

Setting $s = 0$ in (A4) and (A5) and rearranging, we obtain the following equations:

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[23] In stochastic dynamic optimization problem – such as the current one – optimality conditions can be obtained using either dynamic programming or the Lagrangian method. Though as pointed out by Wickens (2008, p. 442) solution may be more difficult to obtain using the latter approach, because stochastic optimisation problems usually involve expectations of random variables. This, in turn, makes it difficult to eliminate the Lagrange multiplier in equation (A5) using (A4), given that itself is a random variable and that $E_t(X_{t+s}Y_{t+s}) \neq E_t(X_{t+s})E_t(Y_{t+s}); s > 0$. Chow (1992, 1993, 1997), however, extensively demonstrate that either of the two methods can yield the same result. In particular, as pointed out by Pfeifer (2014), using the Law of iterated expectations, $E_t\big(E_{t+1}(X_{t+2})\big) = E_t(X_{t+2})$, it is possible to eliminate the Lagrange multipliers by substituting (A4) and (A5). The intuition is that, although the household do not know about future variables, since these conditions (A4) and (A5) hold every period and expectations are rational, they know that, for example, $\Lambda_{t+1} = (C_{t+1} + \varphi G_{t+1})^{-\alpha_c}$ for any realisation of Λ_{t+1}. The Lagrangian method which we use here, as suggested by Chow, has been applied extensively in studies involving stochastic optimisation problems, see Christoffel et al. (2008) and Sbordone et al. (2010), among others.

$$\Lambda_t = (C_t + \varphi G_t)^{-\alpha_c}, \tag{A4'}$$

$$\Lambda_t = \beta E_t[\Lambda_{t+1}(1 + r_{t+1} - \delta)], \tag{A5'}$$

which corresponds to equations (4) and (5) in the text.

3A.2 Final Good Sector's Optimisation Problem

The composite final good is aggregated according to the following CES function,

$$Y_t = \left[\int_0^1 y_{it}^{\frac{\varepsilon_t - 1}{\varepsilon_t}} di\right]^{\frac{\varepsilon_t}{\varepsilon_t - 1}}. \tag{A6}$$

The sector maximises its profit,

$$\Pi_t^Y = P_t Y_t - \int_0^1 p_{it} y_{it}\, di,$$

subject to equation (A6). We can then rewrite the sector's problem at time t as

$$\Pi_t^Y = \left[\int_0^1 y_{it}^{\frac{\varepsilon_t - 1}{\varepsilon_t}} di\right]^{\frac{\varepsilon_t}{\varepsilon_t - 1}} - \frac{1}{P_t}\int_0^1 p_{it} y_{it}\, di.$$

Maximisation with respect to y_{it} yields

$$\frac{\varepsilon_t}{\varepsilon_t - 1}\left[\int_0^1 y_{it}^{\frac{\varepsilon_t - 1}{\varepsilon_t}} di\right]^{\frac{1}{\varepsilon_t - 1}} \frac{\varepsilon_t - 1}{\varepsilon_t} y_{it}^{\frac{-1}{\varepsilon_t}} - \frac{p_{it}}{P_t} = 0,$$

$$\left[\int_0^1 y_{it}^{\frac{\varepsilon_t - 1}{\varepsilon_t}} di\right]^{\frac{1}{\varepsilon_t - 1}} y_{it}^{\frac{-1}{\varepsilon_t}} - \frac{p_{it}}{P_t} = 0,$$

$$\left[Y_t^{\frac{\varepsilon_t - 1}{\varepsilon_t}}\right]^{\frac{1}{\varepsilon_t - 1}} y_{it}^{\frac{-1}{\varepsilon_t}} - \frac{p_{it}}{P_t} = 0,$$

$$Y_t^{\frac{1}{\varepsilon_t}} y_{it}^{-\frac{1}{\varepsilon_t}} = \frac{p_{it}}{P_t},$$

$$y_{it} = \left(\frac{p_{it}}{P_t}\right)^{-\varepsilon_t} Y_t. \tag{A7}$$

3A.3 Intermediate Sector's Optimisation Problem

Each firm in this sector maximises the present discounted value of expected profit given by

$$max\ E_t \sum_{s=0}^{\infty} \lambda_{t,t+s} \left[\frac{p_{it+s}}{P_{t+s}}\, y_{it+s} - n_{it+s} w_{it+s} h_{it+s} - r_{t+s} k_{it+s} - (1 - \zeta_{t+s}^V) x v_{it+s} \right.$$
$$\left. - \eta n_{it+s} F_{t+s}\right],$$

subject to demand function

$$y_{it+s} = \left(\frac{p_{it+s}}{P_{t+s}}\right)^{-\varepsilon_{t+s}} Y_{t+s}, \tag{A8}$$

the production function

$$y_{it+s} = z_{t+s}\left(\frac{n_{it+s}h_{it+s}}{\phi}\right)^{\phi}\left(\frac{k_{it+s}}{1-\phi}\right)^{1-\phi}, \qquad (A9)$$

and the law of motion of employment at firm level

$$n_{it+s} = (1-\eta)n_{it+s-1} + q^{f}_{t+s}v_{it+s}. \qquad (A10)$$

Substituting (A8) into the profit function yields

$$max\ E_t\sum_{s=0}^{\infty}\lambda_{t+s}\left[\left(\frac{p_{it+s}}{P_{t+s}}\right)^{1-\mathcal{E}_{t+s}}Y_{t+s} - n_{it+s}w_{it+s}h_{it+s} - r_{t+s}k_{it+s} - (1-\zeta^{V}_{t+s})xv_{it+s} - \eta n_{it+s}F_{t+s}\right].$$

Let J_{it} and mc_{it} denote the respective Lagrange multipliers associated with the constraints (A9) and (A10). The Lagrangian for each firm is written as

$$L_i = E_t\sum_{s=0}^{\infty}\lambda_{t+s}\left[\left\{\left(\frac{p_{it+s}}{P_{t+s}}\right)^{1-\mathcal{E}_{t+s}}Y_{t+s} - n_{it+s}w_{it+s}h_{it+s} - r_{t+s}k_{it+s} - (1-\zeta^{V}_{t+s})xv_{it+s} - \eta n_{it+s}F_{t+s}\right\} + mc_{it+s}\left\{z_{t+s}(n_{it+s}h_{it+s})^{\phi}k_{it+s}^{(1-\phi)} - \left(\frac{p_{it+s}}{P_{t+s}}\right)^{-\mathcal{E}_{t+s}}Y_{t+s}\right\} + J_{it+s}\left\{(1-\eta)n_{it+s-1} + q^{f}_{t+s}v_{it+s} - n_{it+s}\right\}\right].$$

The FOCs w.r.t. $\{p_{it+s}\}, \{v_{it+s}\}, \{n_{it+s}\}$ and $\{k_{it+s}\}$ are summarised, for $s = 0$, as follows

$$p_{it}: \qquad p_{it} = \frac{\mathcal{E}_t}{\mathcal{E}_t - 1}mc_{it}P_t,$$

$$v_{it}: \qquad \frac{(1-\zeta^{V}_t)x}{q^{f}_t} = J_{it},$$

$$n_{it}:\ J_{it} = mc_{it}z_t\left(\frac{n_{it}h_{it}}{\phi}\right)^{\phi-1}\left(\frac{k_{it}}{1-\phi}\right)^{1-\phi}h_{it} - w_{it}h_{it} - \eta F_t + (1-\eta)E_t\lambda_{t+1}J_{it+1},$$

and

$$k_{it}: \qquad mc_{it}z_t\left(\frac{n_{it}h_{it}}{\phi}\right)^{\phi}\left(\frac{k_{it}}{1-\phi}\right)^{-\phi} = r_t.$$

The above optimal choices constitute equations (16), (17), (18) and (19) in the text.

3A.4 Wage Determination

Maximisation of the weighted product of both parties' surplus with respect to wage yields

$$\Phi\frac{\partial W_{it}}{\partial w_{it}}J_{it} + (1-\Phi)\frac{\partial J_{it}}{\partial w_{it}}W_{it} = 0,$$

where $\frac{\partial W_{it}}{\partial w_{it}} = h_{it}(1-\tau_t)$ and $\frac{\partial J_{it}}{\partial w_{it}} = -h_{it}$, which gives rise to the following

$$\Phi(1-\tau_t)J_{it} = (1-\Phi)W_{it}. \qquad (A11)$$

Noting that $S_{it} = J_{it} + W_{it}$ yields the effective surplus sharing relationships

$$W_{it} = \frac{\Phi(1-\tau_t)}{(1-\Phi\tau_t)}S_{it} \text{ and } J_{it} = \frac{(1-\Phi)}{(1-\Phi\tau_t)}S_{it}.$$

As in Krause et al. (2008), using equations (17) and (A11) we have

$$\frac{(1-\zeta_t^V)x}{q_{\mathrm{t}}^f} = J_{it} = W_{it}\ \frac{(1-\Phi)}{\Phi(1-\tau_t)}\ \Rightarrow W_{it} = \frac{(1-\zeta_t^V)x}{q_{\mathrm{t}}^f}\frac{\Phi(1-\tau_t)}{(1-\Phi)}. \qquad (A12)$$

To obtain the real wage, we substitute the value equations (18) and (21) into (A11). Thus

$$\Rightarrow \Phi(1-\tau_t)\left[\frac{mc_{it}\phi y_{it}}{n_{it}} - w_{it}h_{it} - \eta F_t + (1-\eta)E_t\lambda_{t+1}J_{it+1}\right] =$$

$$(1-\Phi)\left[(1-\tau_t)w_{it}h_{it} - \left[b_t + \frac{\mathrm{A}(h_{it})}{\Lambda_t}\right] + \eta B + \zeta_t^w + (1-\eta)E_t\lambda_{t+1}(1-q_{t+1}^w)W_{it+1}\right],$$

$$\Rightarrow -\Phi(1-\tau_t)w_{it}h_{it} - (1-\Phi)(1-\tau_t)w_{it}h_{it} =$$

$$-\Phi(1-\tau_t)\left[\frac{mc_{it}\phi y_{it}}{n_{it}} - \eta F_t + (1-\eta)E_t\lambda_{t+1}J_{it+1}\right]$$

$$-(1-\Phi)\left[\left(b_t + \frac{A(h_{it})}{\Lambda_t}\right) - \zeta_t^w - \eta B - (1-\eta)(1-q_{t+1}^w)E_t\lambda_{t+1}W_{it+1}\right],$$

$$\Rightarrow (1-\tau_t)w_{it}h_{it} = \Phi(1-\tau_t)\left[\frac{mc_{it}\phi y_{it}}{n_{it}} - \eta F_t + (1-\eta)E_t\lambda_{t+1}J_{it+1}\right]$$

$$+(1-\Phi)\left[\left(b_t + \frac{A(h_{it})}{\Lambda_t}\right) - \zeta_t^w - \eta B - (1-\eta)(1-q_{t+1}^w)E_t\lambda_{t+1}W_{it+1}\right].$$

Using the fact that $F_t = PC_t + B$, we have

$$\Rightarrow -\Phi(1-\tau_t)\eta(PC_t + B) - (1-\Phi)\eta B,$$

$$\Rightarrow -\Phi(1-\tau_t)\eta PC_t - (1-\Phi\tau_t)\eta B.$$

Substituting this into the wage equation, and making use of equation (A12) above, gives

$$\Rightarrow w_{it}h_{it} = \Phi\left(\frac{mc_{it}\phi y_{it}}{n_{it}} - \eta\left(\alpha_t^f + \eta^w B\right) + (1-\eta)E_t\lambda_{t+1}\frac{(1-\zeta_{t+1}^V)x}{q_{\mathrm{t+1}}^f}\right) +$$

$$\left(\frac{1-\Phi}{1-\tau_t}\right)\left(b_t + \frac{\mathrm{A}(h_{it})}{\Lambda_t} - \zeta_t^w - (1-\eta)E_t\lambda_{t+1}\frac{(1-\zeta_{t+1}^V)x}{q(\theta_{t+1})}\frac{\Phi E_t(1-\tau_{t+1})}{(1-\Phi)}\right) - \frac{(1-\Phi\tau_t)\eta B}{(1-\tau_t)},$$

$$\Rightarrow w_{it}h_{it} = \Phi\left(\frac{mc_t\phi y_{it}}{n_{it}} - \eta\left(\alpha_t^f + \eta^w B\right)\right) + \Phi\left((1-\eta)E_t\lambda_{,t+1}\frac{(1-\zeta_{t+1}^V)x}{q_{t+1}^f}\right)\times$$

$$\left(1-(1-q_{t+1}^w)\frac{(1-\tau_{t+1})}{(1-\tau_t)}\right) + \left(\frac{1-\Phi}{1-\tau_t}\right)\left(b_t + \frac{Ah_{it}^{1+\alpha_h}}{\Lambda_t(1+\alpha_h)} - \zeta_t^w\right) - \frac{(1-\Phi\tau_t)\eta B}{(1-\tau_t)}.$$

The above is the wage equation that appears in the text (i.e. equation (25)). In the absence of tax, $\tau_t = \tau_{t+1} = 0$, the wage schedule becomes

$$w_{it}h_{it} = \Phi\left(\frac{mc_{it}\phi y_{it}}{n_{it}} - \eta\left(\alpha_t^f + \eta^w B\right) + (1-\eta)E_t\lambda_{t+1}\theta_{t+1}(1-\zeta_{t+1}^V)x\right)$$

$$+(1-\Phi)\left(b_t + \frac{\mathrm{A}(h_{it})}{\Lambda_t} - \zeta_t^w\right) - \eta B. \qquad (A13)$$

3B Summary of Equation System

Here we summarise the equilibrium system by presenting each equation (Eq), the steady state (SS) and log-linearised (LL) versions. Note that in the absence of shocks, the economy converges to a steady state where all endogenous variables are constant. Hence, the steady state versions of the equations described below are obtained by dropping time subscripts from the original equation and assuming away shock, i.e., $\psi_z = \psi_l = 0$. The log-linearised version of the model is obtained using first order Taylor series approximation around the steady state to replace each equation with approximation, which are linear in the log-deviations of the variables.

Law of motion for capital:

Eq: $K_{t+1} = I_t + (1-\delta)K_t$.

SS: $\bar{I} = \delta\bar{K}$.

LL: $\widehat{K}_{t+1} = \delta\hat{I}_t + (1-\delta)\widehat{K}_t$.

Marginal utility of consumption:

Eq: $\Lambda_t = (C_t + \varphi G_t)^{-\alpha_c}$.

SS: $\bar{\Lambda} = (\bar{C} + \varphi\bar{G})^{-\alpha_c}$.

LL: $\hat{\Lambda}_t = -\frac{\alpha_c}{(\bar{C}+\varphi\bar{G})}\left(\bar{C}\hat{C}_t + \varphi\bar{G}\hat{G}_t\right)$.

Household Euler equation:

Eq: $\Lambda_t = \beta E_t[\Lambda_{t+1}(1 + r_{t+1} - \delta)]$.

SS: $\frac{1}{\beta} = (1 + r - \delta)$.

LL: $\hat{\Lambda}_t = E_t(\hat{\Lambda}_{t+1} + \beta\bar{r}\hat{r}_{t+1})$.

Aggregate productivity:

Eq: $Y_t = z_t\left(\frac{N_t h_t}{\phi}\right)^{\phi}\left(\frac{K_t}{1-\phi}\right)^{1-\phi}$.

SS: $\bar{Y} = \bar{z}\left(\frac{\bar{N}\bar{h}}{\phi}\right)^{\phi}\left(\frac{\bar{K}}{1-\phi}\right)^{1-\phi}$.

LL: $\hat{Y}_t = \hat{z}_t + \phi\left(\hat{N}_t + \hat{h}_t\right) + (1-\phi)\widehat{K}_t$.

New Matches:

Eq: $M_t = M_t(U_t, V_t) = \chi U_t^{\gamma} V_t^{1-\gamma}$.

SS: $\bar{M} = \chi\bar{U}^{\gamma}\bar{V}^{1-\gamma}$.

LL: $\widehat{M}_t = \gamma\widehat{U}_t + (1-\gamma)\hat{V}_t$.

Market tightness:

Eq: $\theta_t = V_t/U_t$.

SS: $\bar{\theta} = \bar{V}/\bar{U}$.

LL: $\hat{\theta}_t = \hat{V}_t - \widehat{U}_t$.

Vacancy filling rate:

Eq: $q_t^f = \chi\theta_t^{-\gamma}$.

SS: $\bar{q}^f = \chi\bar{\theta}^{-\gamma}$.

LL: $\hat{q}_t^f = -\gamma\hat{\theta}_t$.

Job finding rate:

Eq: $q_t^w = \chi\theta_t^{1-\gamma}$.

SS: $\bar{q}^w = \chi\bar{\theta}^{1-\gamma}$.

LL: $\hat{q}_t^w = (1-\gamma)\hat{\theta}_t$.

Aggregate employment:

Eq: $N_t = (1-\eta)N_{t-1} + M_t$.

SS: $\eta\bar{N} = \bar{M}$.

LL: $\bar{N}\hat{N}_t = (1-\eta)\bar{N}\hat{N}_{t-1} + \bar{M}\hat{M}_t$.

Aggregate unemployment:

Eq: $U_t = [1-N_{t-1}] + \eta N_{t-1}$.

Eq: $\bar{U} = 1-(1-\eta)\bar{N}$.

LL: $\bar{U}\hat{U}_t = -(1-\eta)\bar{N}\hat{N}_{t-1}$.

Marginal cost (the inverse of mark-up):

Eq: $mc_t = \frac{\mathcal{E}_t - 1}{\mathcal{E}_t}$.

SS: $\overline{mc} = \frac{\bar{\mathcal{E}}-1}{\bar{\mathcal{E}}}$.

LL: $\widehat{mc}_t = \frac{1}{\bar{\mathcal{E}}-1}\hat{\mathcal{E}}_t$.

Optimal choice of capital:

Eq: $r_t = mc_t(1-\phi)\frac{Y_t}{K_t}$.

SS: $\bar{r} = \overline{mc}(1-\phi)\frac{\bar{Y}}{\bar{K}}$.

LL: $\hat{r}_t = \widehat{mc}_t + \hat{Y}_t - \hat{K}_t$.

Job creation condition:

Eq: $\frac{(1-\zeta_t^V)x}{q_t^f} = \frac{mc_t\phi Y_t}{N_t} - w_t h_t - \eta F_t + (1-\eta)\beta E_t \frac{\Lambda_{t+1}}{\Lambda_t}\frac{(1-\zeta_{t+1}^V)x}{q_{t+1}^f}$.

SS: $\frac{[1-(1-\eta)\beta](1-\bar{\zeta}^V)x}{\bar{q}^f} = \frac{\overline{mc}\phi\bar{Y}}{\bar{N}} - \bar{w}\bar{h} - \eta\bar{F}$.

LL: $-\left\{\frac{\bar{\zeta}^V\hat{\zeta}_t^V}{(1-\bar{\zeta}^V)} + \hat{q}_t^f\right\} = \frac{\overline{mc}\phi\bar{Y}}{\bar{N}}\left(\widehat{mc}_t + \hat{Y}_t - \hat{N}_t\right) - \bar{w}\bar{h}\left(\hat{w}_t + \hat{h}_t\right) - \eta\bar{F}\hat{F}_t$

$+ \frac{(1-\eta)\beta(1-\bar{\zeta}^V)x}{\bar{q}^f}\left\{\hat{\Lambda}_{t+1} - \hat{\Lambda}_t - \frac{\bar{\zeta}^V\hat{\zeta}_{t+1}^V}{(1-\bar{\zeta}^V)} - \hat{q}_{t+1}^f\right\}$.

Wage bill:

Eq: $w_t h_t = \Phi\left\{\frac{mc_t\phi Y_t}{N_t} - \eta\left(\alpha_t^f + \eta^w B\right) + \frac{(1-\eta)E_t\lambda_{t+1}(1-\zeta_{t+1}^V)x}{q_{t+1}^f}\left[1-(1-q_{t+1}^w)\frac{(1-\tau_{t+1})}{(1-\tau_t)}\right]\right\}$

$+(1-\Phi)\left\{\frac{b_t-\zeta_t^W}{1-\tau_t} + \frac{\phi^2 mc_t Y_t}{(1+\alpha_h)N_t}\right\} - \frac{(1-\Phi\tau_t)\eta B}{(1-\tau_t)}$.

SS: $wh = \Phi\left\{\frac{\overline{mc}\phi\bar{Y}}{\bar{N}} - \eta(\bar{\alpha}^f + \eta^w B) + (1-\eta)\beta(1-\zeta^V)x\bar{\theta}\right\}$

$+(1-\Phi)\left\{\frac{b-\zeta^W}{1-\tau} + \frac{\phi^2 mc\bar{Y}}{(1+\alpha_h)\bar{N}}\right\} - \frac{(1-\Phi\tau)\eta B}{(1-\tau)}$.

$$\text{LL: } \bar{w}\bar{h}(\hat{w}_t + \hat{h}_t) = \Phi\left\{\frac{\overline{mc}\phi\bar{Y}}{\bar{N}}\left(\widehat{mc}_t + \hat{Y}_t - \hat{N}_t\right) - \eta\bar{\alpha}^f\hat{\alpha}_t^f\right\}$$
$$+ \Phi(1-\eta)\beta(1-\bar{\zeta}^V)x\bar{\theta}\left\{\Lambda_{t+1} - \Lambda_t + \hat{\theta}_{t+1} - \frac{\zeta^V\zeta_{t+1}^V}{1-\zeta^V} + \frac{\tau(\tau_{t+1}-\tau_t)}{q^w(1-\tau)}\right\}$$
$$+ \frac{(1-\Phi)}{(1-\tau)}\left\{\bar{b}\hat{b}_t - \zeta^w\hat{\zeta}_t^w + \frac{(b-\zeta^w-\eta B)\tau\hat{\tau}_t}{(1-\tau)} + \frac{(1-\tau)\phi^2 mc\bar{Y}}{(1+\alpha_h)\bar{N}}\left(\widehat{mc}_t + \hat{Y}_t - \hat{N}_t\right)\right\}.$$

Hours of work

$$\text{Eq: } \frac{Ah_t^{(1+\alpha_h)}}{(1-\tau_t)\Lambda_t} = \frac{\phi^2 mc_t Y_t}{N_t}.$$
$$\text{SS: } \frac{Ah^{(1+\alpha_h)}}{(1-\bar{\tau})\bar{\Lambda}} = \frac{\phi^2\overline{mc}\bar{Y}}{\bar{N}}.$$
$$\text{LL: } (1+\alpha_h)\hat{h}_t + \frac{\bar{\tau}}{(1-\bar{\tau})}\hat{\tau}_t - \hat{\Lambda}_t = \widehat{mc}_t + \hat{Y}_t - \hat{N}_t.$$

Household budget constraint:

$$\text{Eq: } C_t + I_t + T_t = (1-\tau_t)N_t w_t h_t + (1-N_t)b_t + \eta N_t B + N_t\zeta_t^w + r_t K_t + \Pi_t.$$
$$\text{SS: } \bar{C} + \bar{I} + \bar{T} = (1-\bar{\tau})\bar{N}\bar{w}\bar{h} + (1-\bar{N})\bar{b} + \eta\bar{n}B + \bar{N}\bar{\zeta}^w + \bar{r}\bar{K} + \bar{\Pi}.$$
$$\text{LL: } \bar{C}\hat{C}_t + \bar{I}\hat{I}_t + \bar{T}\hat{T}_t = (1-\bar{\tau})\bar{N}\bar{w}\bar{h}\left(\hat{w}_t + \hat{N}_t + \hat{h}_t - \frac{\bar{\tau}}{(1-\bar{\tau})}\hat{\tau}_t\right)$$
$$+ (1-\bar{N})\bar{b}\hat{b}_t + \left(\zeta^w + \eta B - \bar{b}\right)\bar{N}\hat{N}_t + \bar{N}\zeta^w\hat{\zeta}_t^w + \bar{r}\bar{K}(\hat{r}_t + \hat{K}_t) + \bar{\Pi}\hat{\Pi}_t.$$

Profit equation:

$$\text{Eq: } \Pi_t = Y_t - N_t w_t h_t - r_t K_t - (1-\zeta_t^V)xV_t - \eta N_t F_t.$$
$$\text{SS: } \bar{\Pi} = \bar{Y} - \bar{N}\bar{w}\bar{h} - \bar{r}\bar{K} - (1-\bar{\zeta}^V)x\bar{V} - \eta\bar{N}\bar{F}.$$
$$\text{LL: } \bar{\Pi}\hat{\Pi}_t = \bar{Y}\hat{Y}_t - \bar{N}\bar{w}\bar{h}\left(\hat{N}_t + \hat{w}_t + \hat{h}_t\right) - \bar{r}\bar{K}\left(\hat{r}_t + \hat{K}_t\right)$$
$$-\bar{\zeta}^V x\bar{V}\left(\hat{V}_t - \frac{\bar{\zeta}^V\hat{\zeta}_t^V}{(1-\bar{\zeta}^V)}\right) - \eta\bar{n}\bar{F}\left(\hat{N}_t + \hat{F}_t\right).$$

Government budget dynamics:

$$\text{Eq: } T_t + \tau_t N_t w_t h_t + \eta N_t(\alpha_t^f + \eta^w B) = G_t + (1-N_t)b_t + \zeta_t^w N_t + \zeta_t^V xV_t.$$
$$\text{SS: } \bar{T} + \bar{\tau}\bar{N}\bar{w}\bar{h} + \bar{N}\eta(\bar{\alpha}^f + \eta^w B) = \bar{G} + (1-\bar{N})\bar{b} + \bar{\zeta}^w\bar{N} + \bar{\zeta}^V x\bar{V}.$$
$$\text{LL: } \bar{T}\hat{T}_t + \bar{\tau}\bar{N}\bar{w}\bar{h}\left(\hat{\tau}_t + \hat{N}_t + \hat{w}_t + \hat{h}_t\right) + \eta(\bar{\alpha}^f + \eta^w B)\bar{N}\hat{N}_t + \bar{N}\eta\bar{\alpha}^f\hat{\alpha}_t^f =$$
$$\bar{G}\hat{G}_t + (1-\bar{N})\bar{b}\hat{b}_t - \bar{b}N\hat{N}_t + \bar{\zeta}^w\bar{N}\left(\hat{\zeta}_t^w + \hat{N}_t\right) + \bar{\zeta}^V xV\left(\hat{\zeta}_t^V + \hat{V}_t\right).$$

Productivity factor:

$$\hat{z}_t = \rho_z\hat{z}_{t-1} + \psi_{zt}.$$

Autoregressive process of other exogenous variables:

$$\hat{l}_t = \rho_l\hat{l}_{t-1} + \psi_{lt};\ l_t = \mathcal{E}_t, G_t, b_t, \alpha_t^f, \zeta_t^w \text{ and } \zeta_t^V.$$

3C Tables and Figures

Table 3.1: Baseline calibration

Para.	Value	Description	Source
β	0.99	subjective discount factor	Faccini et al. (2013)
δ	0.025	depreciation rate	Zanetti (2011a).
φ	0.1	degree of substitutability	Ahmed (1986)
α_c	0.9	relative risk aversion	See text
α_h	2	inv. of Frisch elasticity	Trigari (2006, 2009)
ϕ	0.69	labour input elasticity	Faccini et al. (2013)
$\bar{\mathcal{E}}$	6	set to target mark-up of 20 percent	Villa and Yang (2011)
γ	0.5	elasticity of match to unemp	Pissarides (1998)
Φ	$(1-\gamma)$	Hosios efficiency condition	Hosios (1990)
η	0.05	job separation rate	Pissarides (1998)
ρ_b	0.38	benefit replacement ratio	Faccini et al. (2011)
χ	0.62994	job match efficiency	See text
τ	0.27	labour tax	Angelopoulos et al. (2012)
A	4	disutility of work measure	Villa and Yang (2011)
$\overline{PC}$	0.3	firing tax	Zanetti (2011a)/See text
x	0.28709	vacancy creation cost	See text

Table 3.2: Data averages and benchmark model's steady state solution

Variable	Data average	Model solution
$\bar{G}/\bar{Y}$	0.2199	0.2199
$\bar{C}/\bar{Y}$	0.5802	0.5823
$\bar{I}/\bar{Y}$	0.1856	0.1840
$\bar{K}/\bar{Y}$	7.4223	7.3597
$\bar{\Pi}/\bar{Y}$	0.1707	0.1695

Table 3.3: Steady state solution and policy comparative statics

Var.	Bench	b	α_f	$\eta^w B$	ζ^V	ζ^w	τ	$\bar{G}$	φ	φ & $\bar{G}^{(2)}$	b & $\zeta^{V(3)}$	b & $\zeta^{w(4)}$
$\bar{Y}$	1.0000	0.9357	0.9990	0.9967	1.0038	1.0199	0.9384	1.0475	0.9779	1.0134	0.9406	1.0000
$\overline{HDI}$	0.9851	0.9641	0.9803	0.9684	0.9882	1.0903	0.9324	1.0304	0.9641	0.9978	0.9670	1.0851
$\bar{C}$	0.5823	0.5376	0.5817	0.5803	0.5845	0.5927	0.5353	0.5201	0.5647	0.4929	0.5413	0.5823
$\bar{K}$	7.3597	6.8865	7.3523	7.3355	7.3874	7.5062	6.9065	7.7096	7.1973	7.4584	6.9229	7.3597
$\bar{\Pi}$	0.1695	0.1572	0.1693	0.1688	0.1700	0.1741	0.1586	0.1777	0.1658	0.1718	0.1580	0.1695
$\bar{h}$	0.3333	0.3450	0.3335	0.3338	0.3328	0.3308	0.3212	0.3472	0.3270	0.3372	0.3440	0.3333
$\bar{w}$	1.6484	1.6810	1.6355	1.5893	1.6507	1.6267	1.6535	1.6523	1.6466	1.6495	1.6820	1.6484
$\bar{V}$	0.0482	0.0209	0.0474	0.0457	0.0513	0.0683	0.0369	0.0515	0.0466	0.0491	0.0221	0.0482
$\bar{\theta}$	0.4899	0.1132	0.4757	0.4455	0.5482	0.9323	0.3031	0.5533	0.4609	0.5077	0.1239	0.4899
$\bar{q}^w$	0.4409	0.2119	0.4345	0.4205	0.4664	0.6082	0.3468	0.4686	0.4276	0.4488	0.2218	0.4409
$\bar{S}$	0.5519	0.2653	0.5438	0.5263	0.5254	0.7613	0.4089	0.5865	0.5352	0.5618	0.2498	0.5519
$\bar{U}$	0.0984	0.1850	0.0997	0.1027	0.0935	0.0733	0.1218	0.0931	0.1011	0.0968	0.1783	0.0984
$\bar{N}$	0.9450	0.8542	0.9436	0.9405	0.9501	0.9713	0.9204	0.9505	0.9421	0.9466	0.8613	0.9450

(1) In all cases we consider 0.1 percentage point increase from the respective benchmark values, except for η^w and φ whose change equal 0.5 and 0.2, respectively. In all instances we allow lump sum tax to adjust to balance government's budget.

(2) An increase in government consumption expenditure, $\bar{G}$, accompanied by an increase in the degree of substitutability, φ.

(3) An increase in unemployment benefit, b, accompanied by an increase in recruitment subsidy, ζ^V.

(4) An increase in unemployment benefit, b, accompanied by an increase in tax subsidy, ζ^w.

Table 3.4: Fiscal employment and output multipliers

		Employment Multiplier				Output Multiplier			
		Q1	**1 year**	**2 years**	**Peak**	**Q1**	**1 year**	**2 years**	**Peak**
Govt. Con. Exp.	Benchmark	0.0029	0.0044	0.0050	0.0052	0.2475	0.2438	0.2386	0.2475
	Fixed firing cost (α_f)	0.0029	0.0047	0.0054	0.0057	0.2475	0.2439	0.2389	0.2475
	Sev. induced cost ($\eta^w B$)	0.0029	0.0045	0.0052	0.0054	0.2475	0.2438	0.2387	0.2475
	Distortionary tax (τ)	0.0029	0.0048	0.0058	0.0063	0.2502	0.2467	0.2417	0.2502
	Unem. benefit (b)	0.0028	0.0053	0.0071	0.0086	0.2488	0.2458	0.2413	0.2488
	Substitutability (φ)	0.0021	0.0033	0.0038	0.0039	0.1842	0.1813	0.1773	0.1842
	Tax financing	-0.0217	-0.0348	-0.0413	-0.0559	-0.4090	-0.4440	-0.4789	-0.7501
Recr. Subsidy	Benchmark	3.0281	4.7103	5.4295	6.1030	1.7219	2.7711	3.3019	4.6731
	Fixed firing cost (α_f)	3.5298	5.7950	6.8967	8.0046	1.9262	3.3367	4.1292	6.1335
	Sev. induced cost ($\eta^w B$)	3.2142	5.1086	5.9612	6.7805	1.7990	2.9797	3.6023	5.1930
	Tax (τ)	3.9744	6.7809	8.2781	9.8828	2.0069	3.6720	4.6814	7.2229
	Unem. Benefit (b)	6.7605	13.2204	18.0072	25.3775	3.0131	7.0299	10.2807	19.6288
	Distotionary tax	3.0587	4.7721	5.5112	6.2261	2.1952	3.7637	4.5719	6.7952
Tax Subsidy	Benchmark	0.0369	0.0506	0.0550	0.0587	0.0181	0.0267	0.0304	0.0428
	Fixed firing cost (α_f)	0.0371	0.0528	0.0582	0.0630	0.0180	0.0277	0.0321	0.0459
	Sev. induced cost ($\eta^w B$)	0.0370	0.0515	0.0563	0.0604	0.0181	0.0271	0.0311	0.0440
	Tax (τ)	0.0431	0.0614	0.0678	0.0734	0.0207	0.0321	0.0372	0.0533
	Unem. benefit (b)	0.0371	0.0591	0.0691	0.0787	0.0171	0.0304	0.0375	0.0570
	Tax financing	0.0190	0.0255	0.0269	0.0270	-0.7861	-0.8089	-0.8426	-1.1317

Figure 3.1: Benchmark impulse responses to a positive TFP shock.

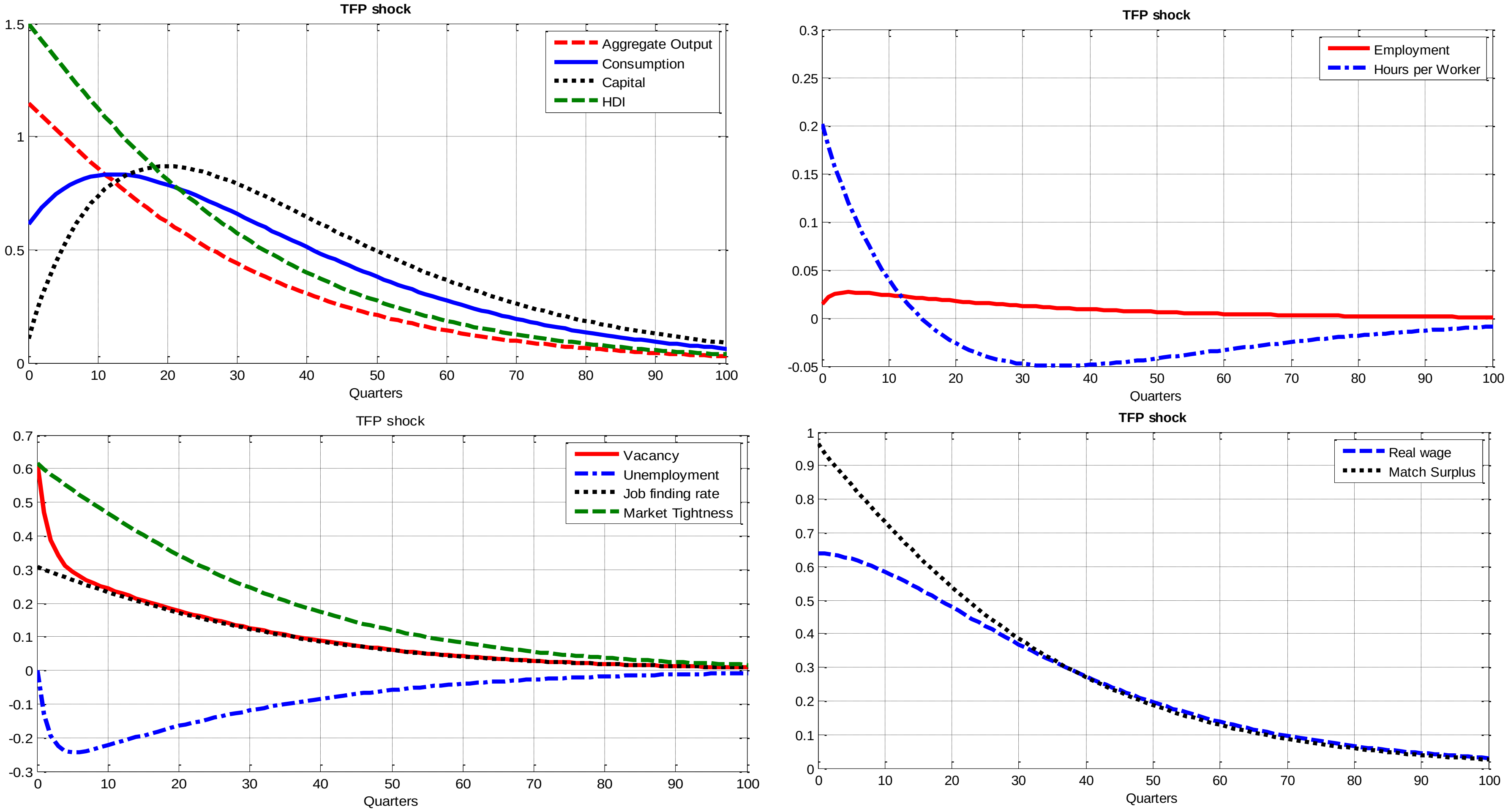


Figure 3.2: Benchmark impulse responses to a positive government consumption shock

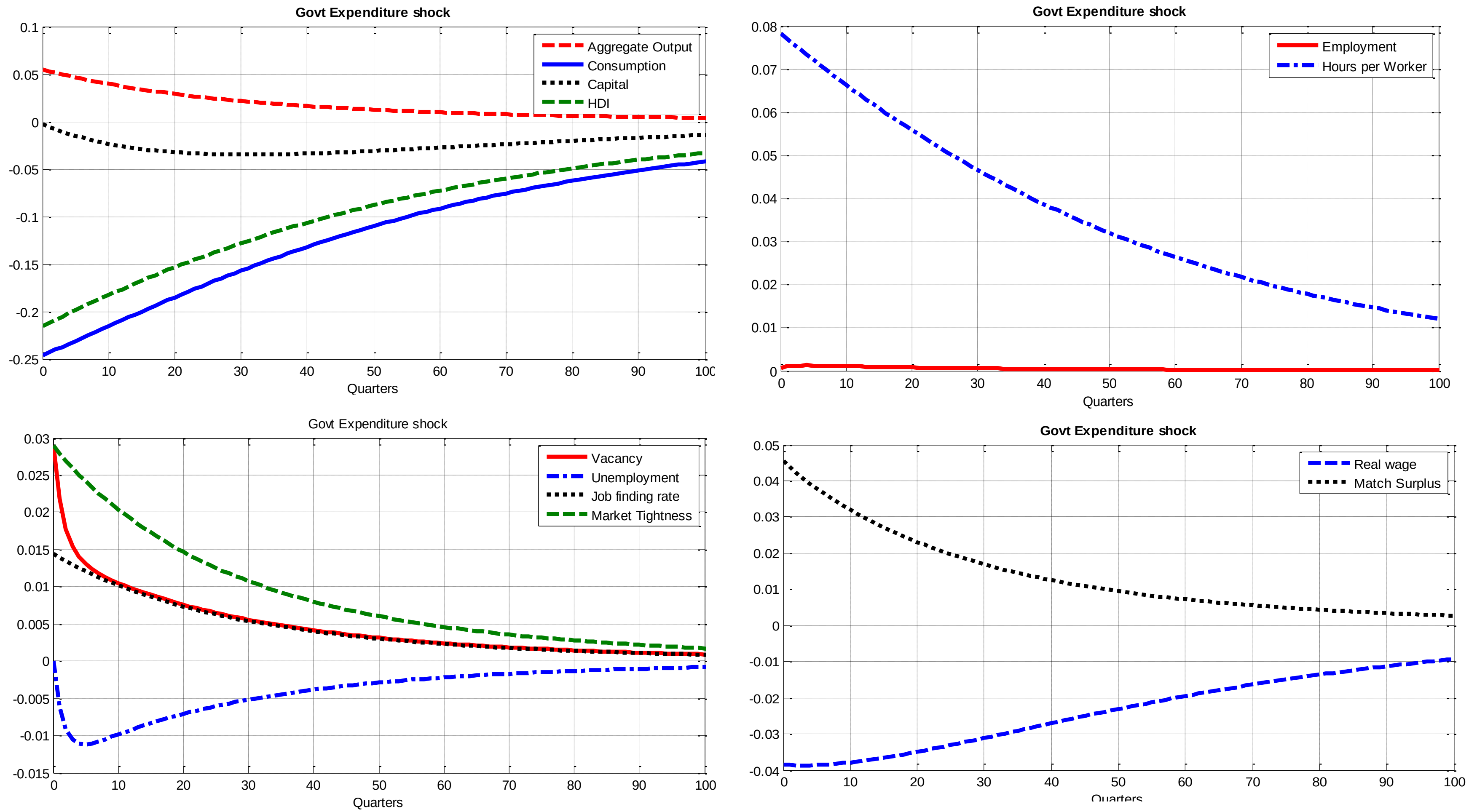


Figure 3.3: Benchmark impulse responses to unemployment insurance shock

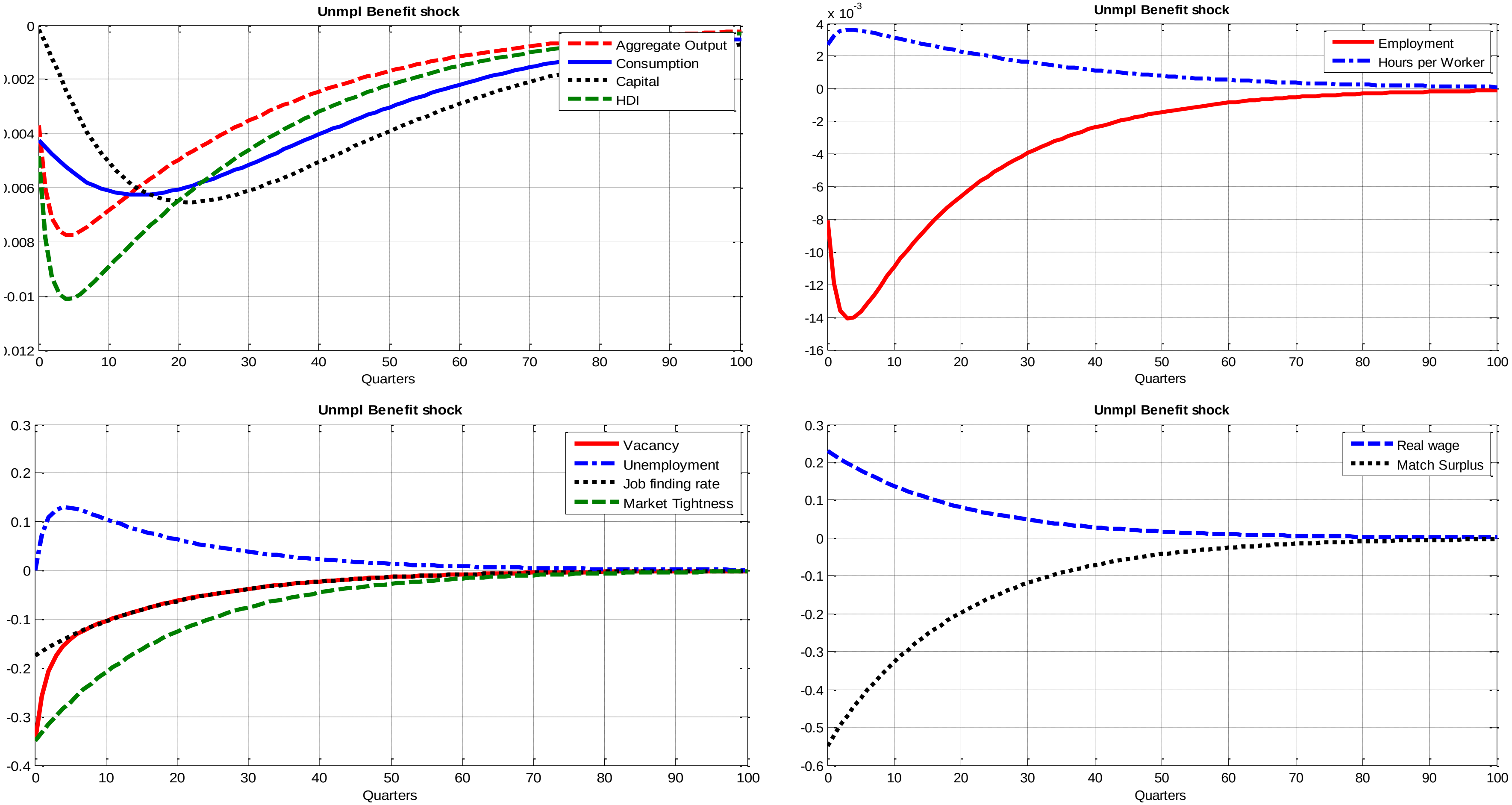


Figure 3.4: Policy reforms and productivity shock

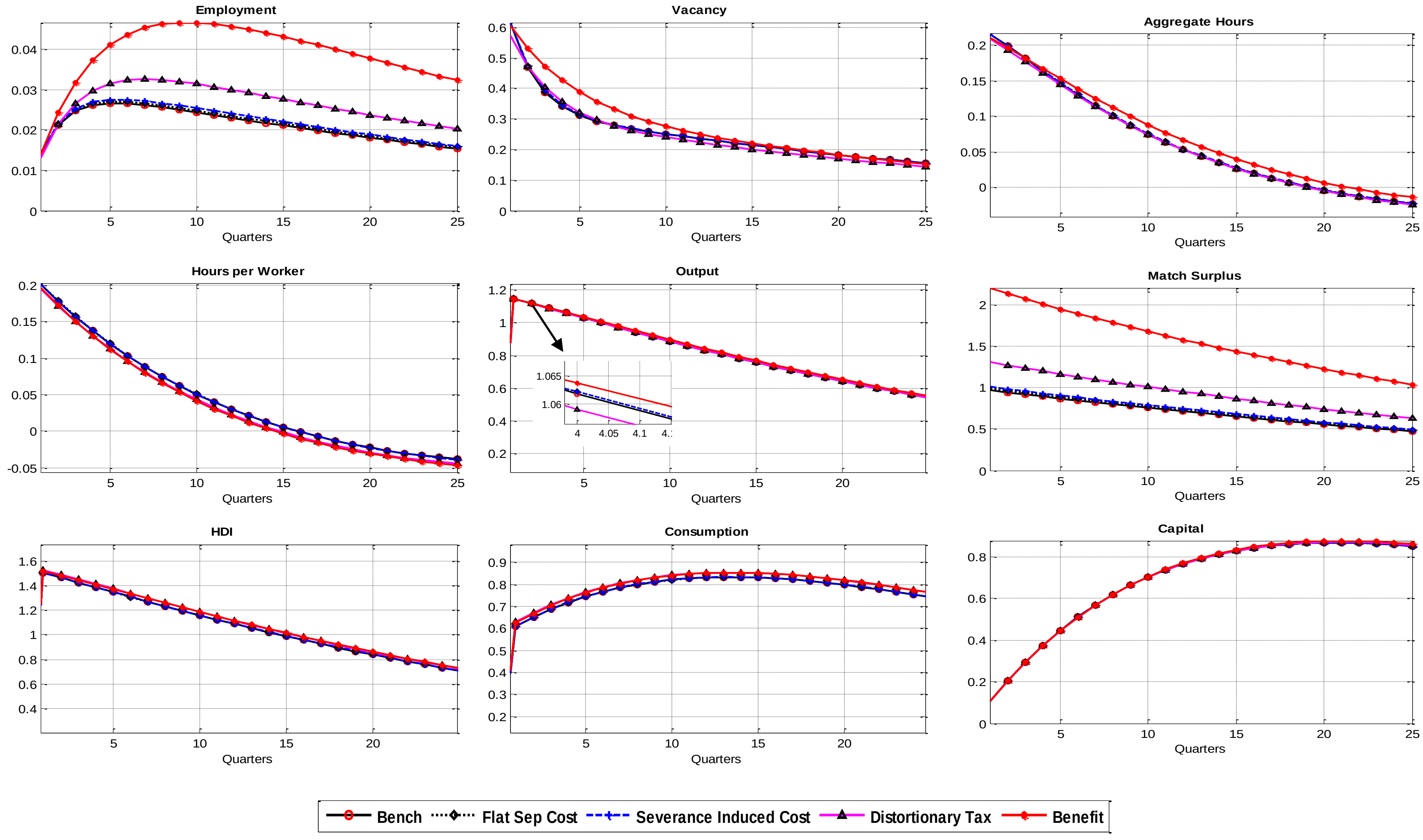


Figure 3.5: Policy Reforms and government consumption spending shock

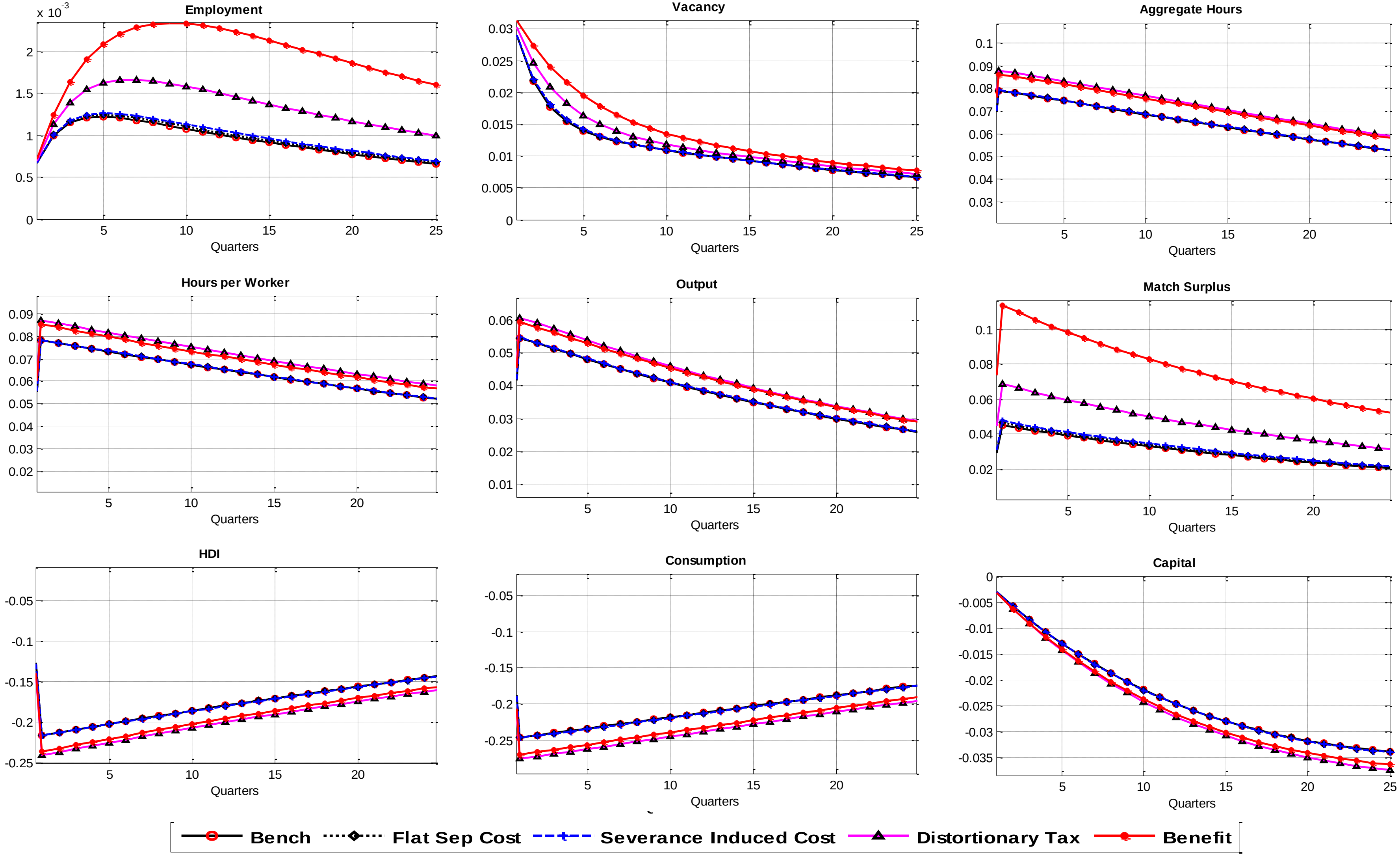


Figure 3.6: Recruitment vs Tax subsidies

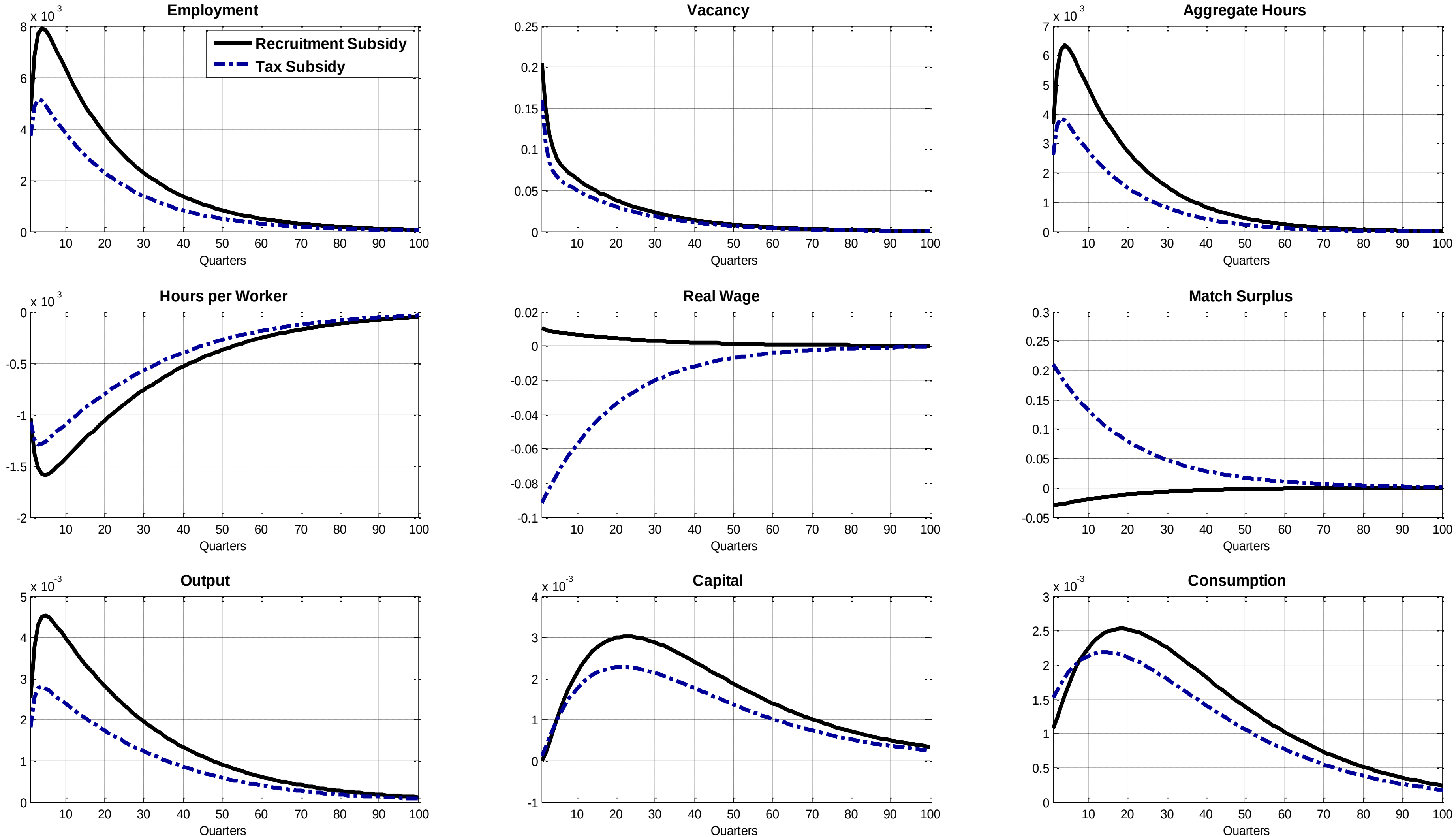


Figure 3.7: Government consumption spending under alternative financing scheme

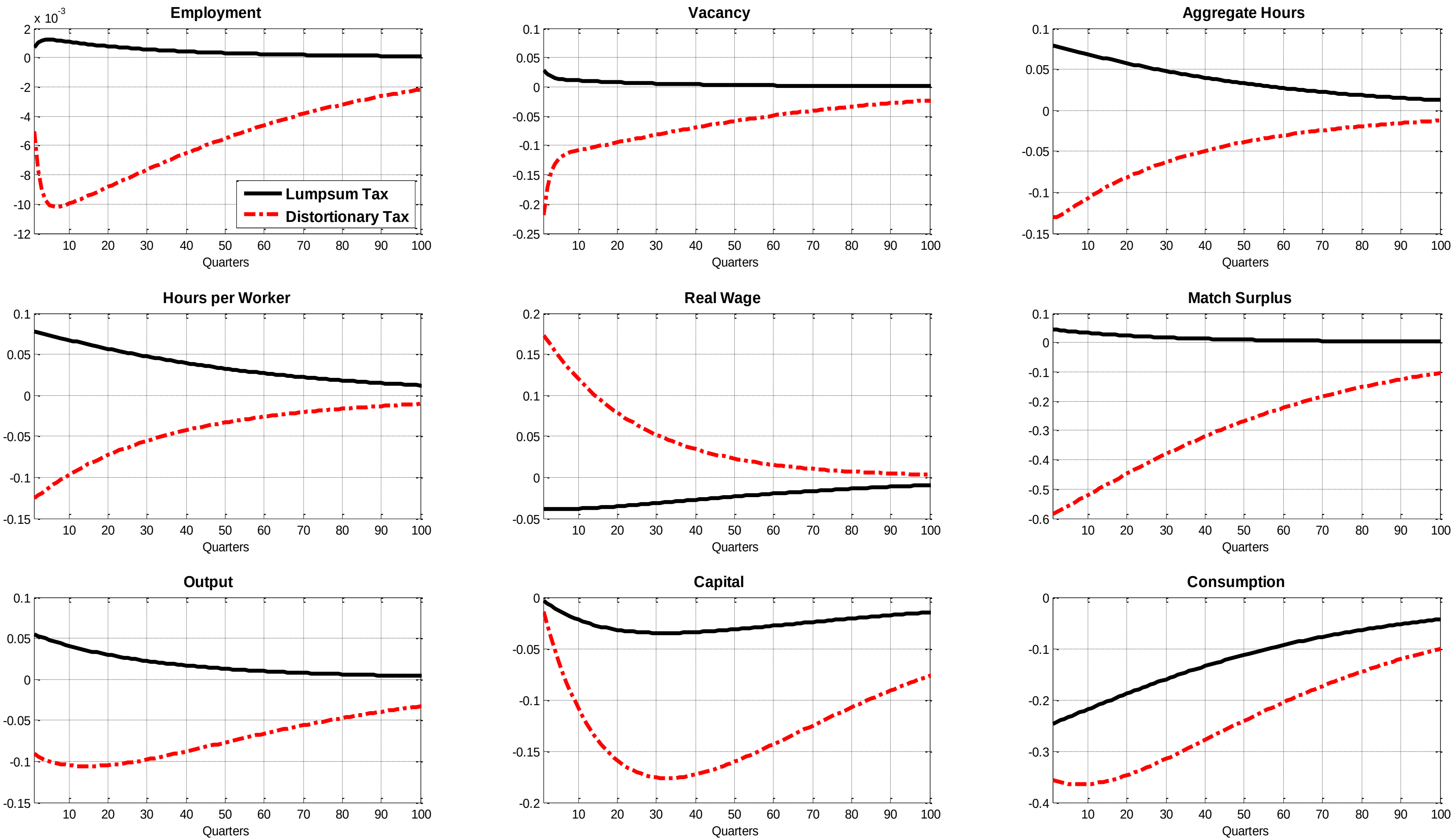


Figure 3.8: Recruitment subsidy under alternative financing scheme

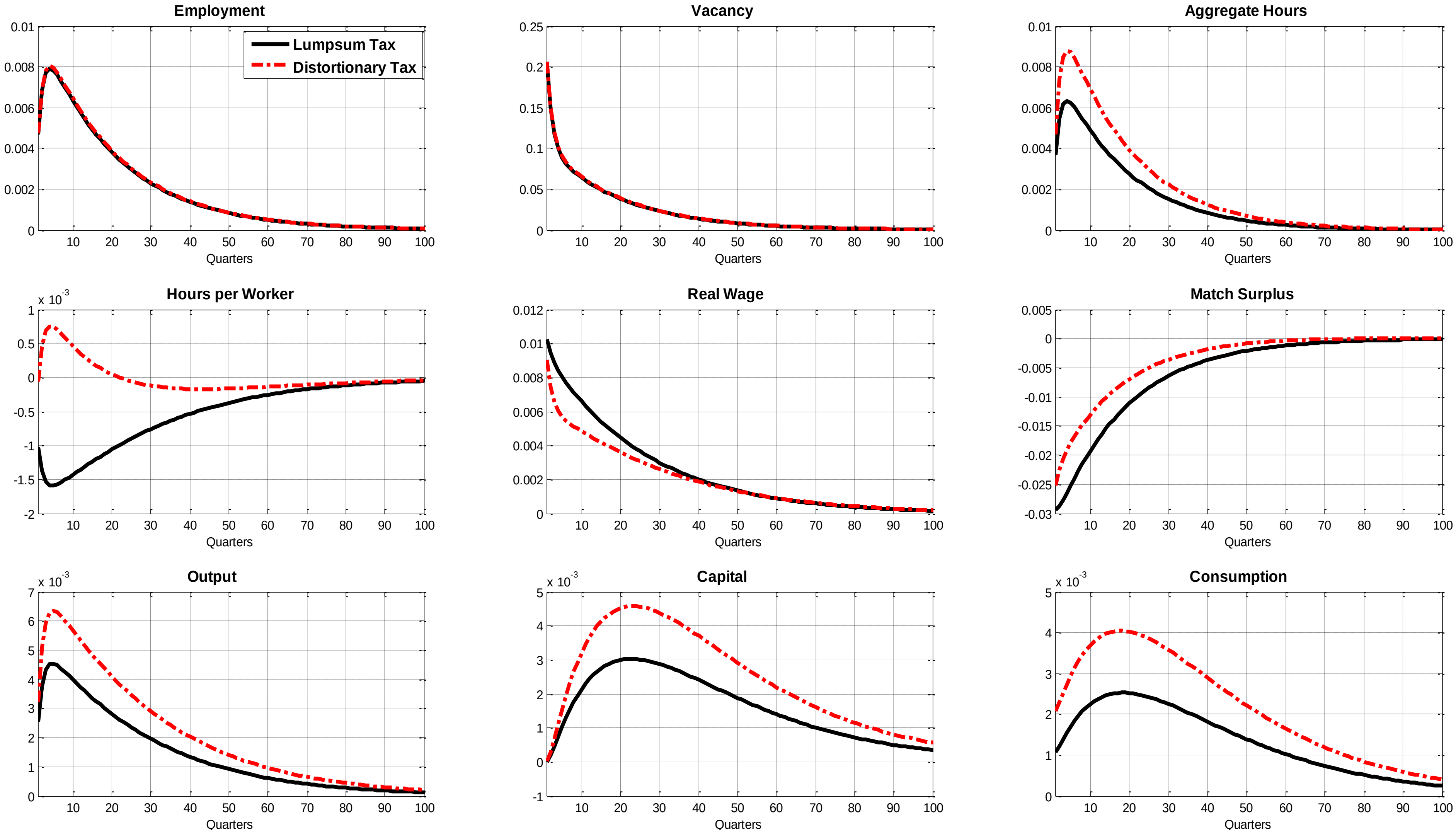


Figure 3.9: Tax subsidy under alternative financing.

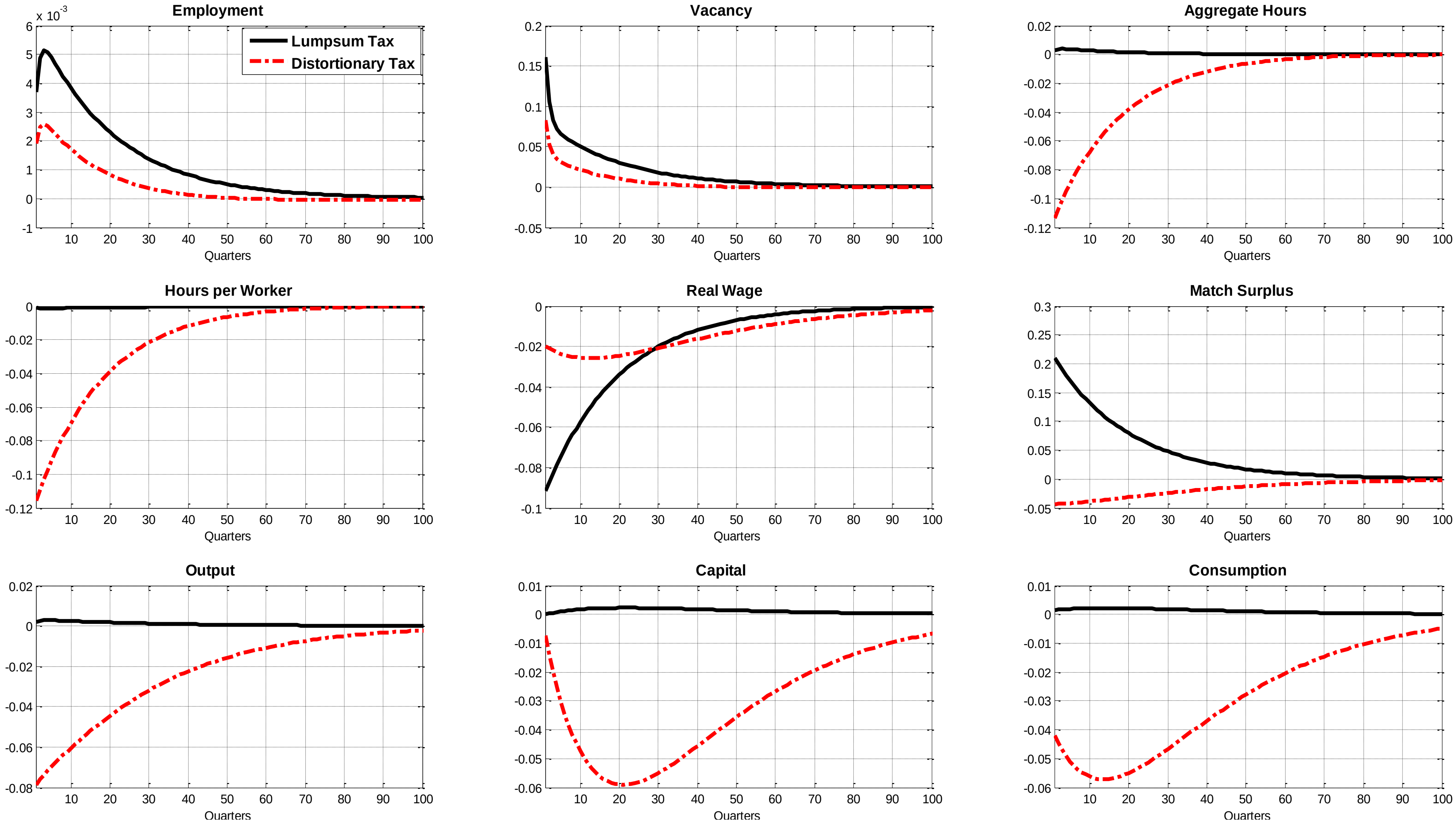


Figure 3.10: Degree of substitutability between private and public consumption

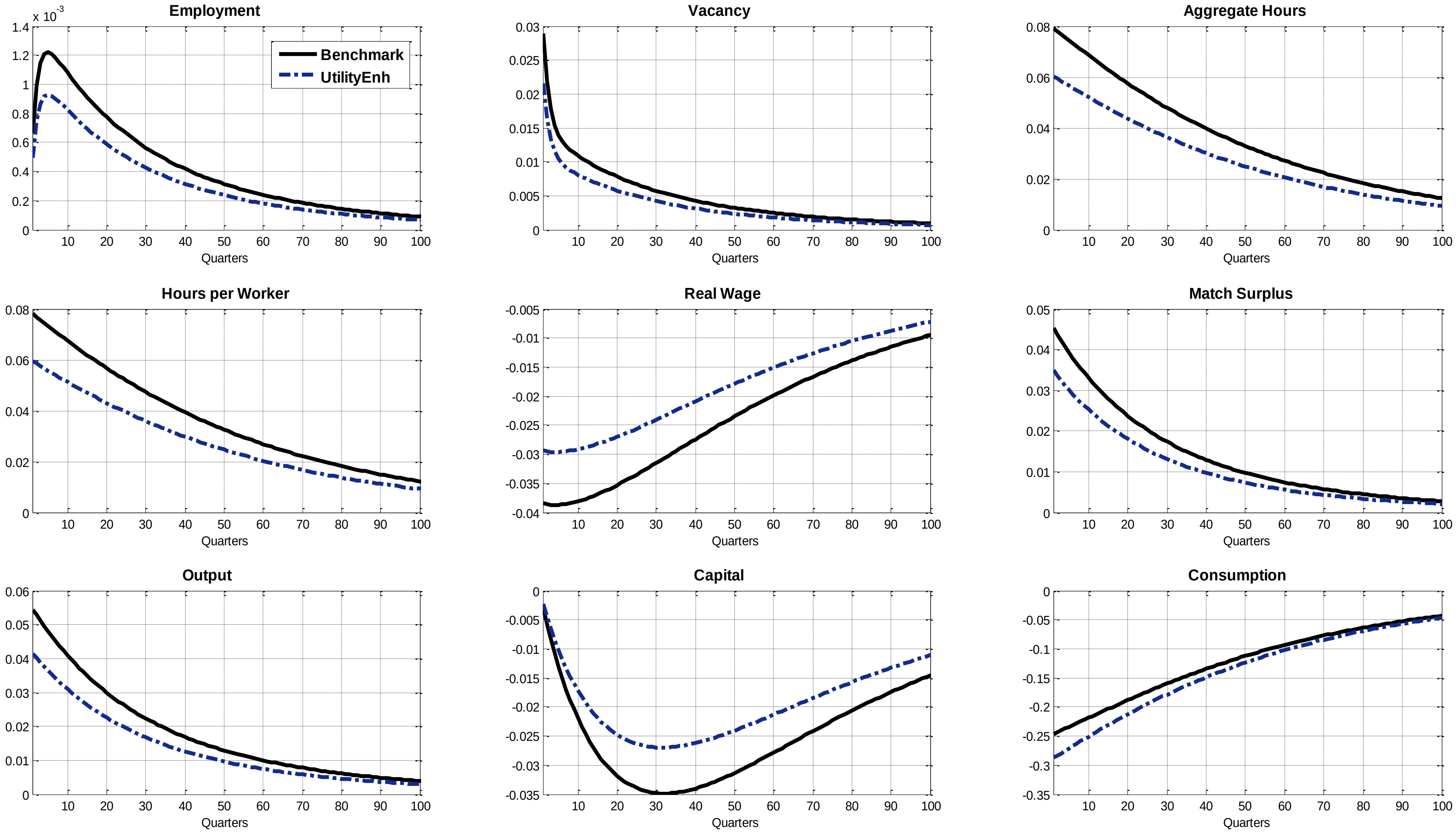


Figure 3.11: Employment multipliers

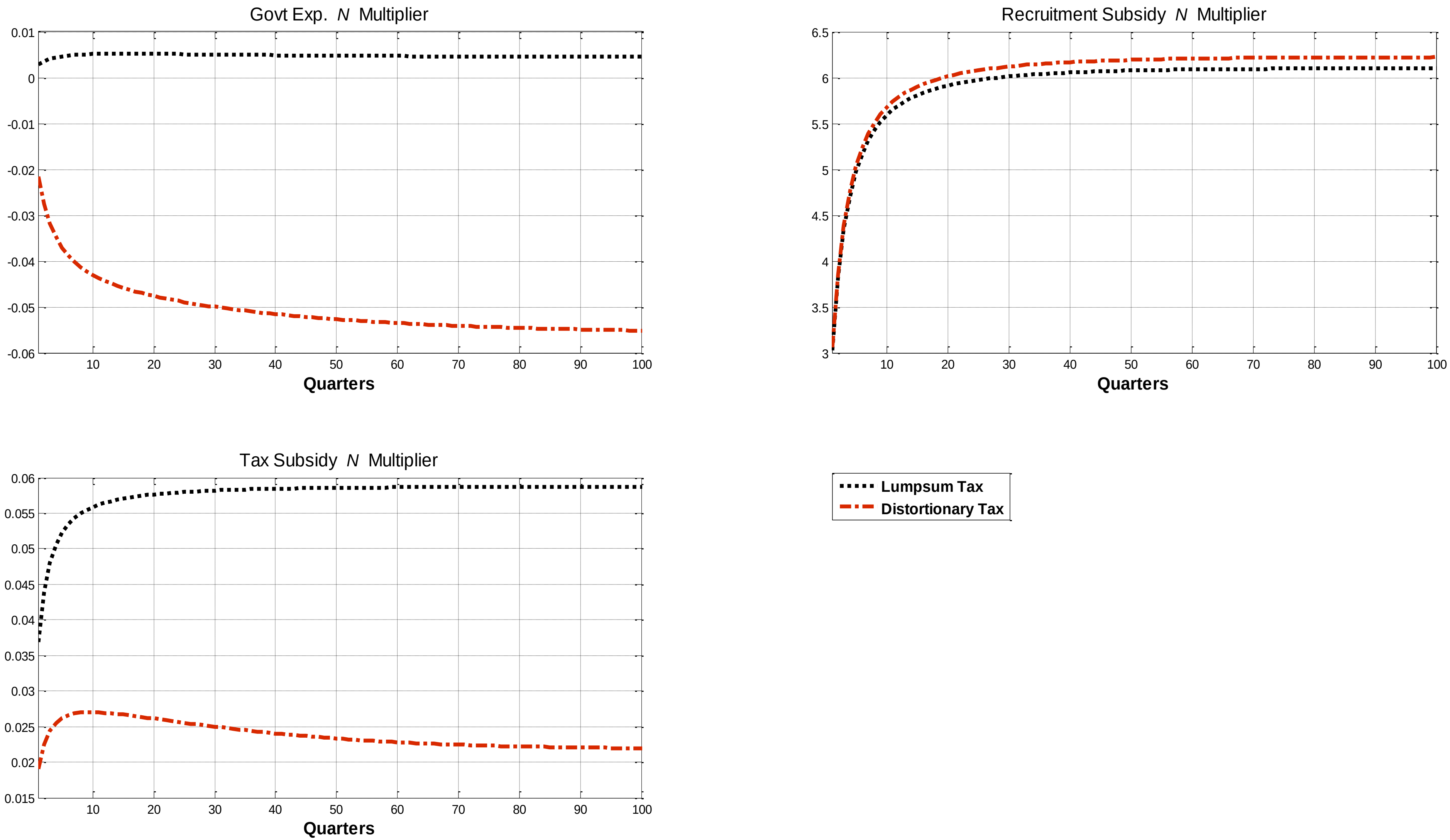
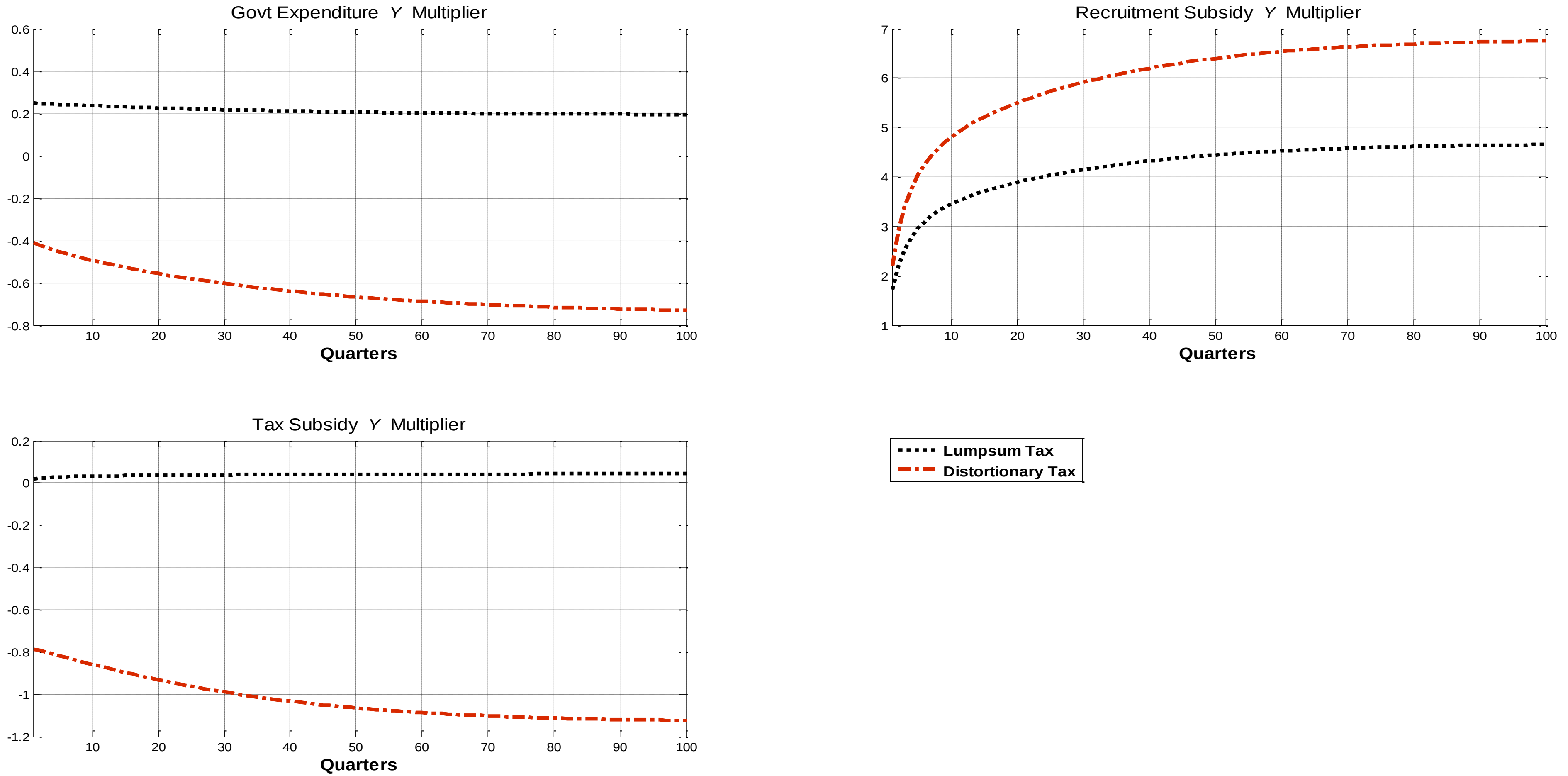


Figure 3.12: Output multipliers



Equation Chapter (Next) Section 1

Chapter 4. Unemployment Dynamics and Economic Openness to International Trade and Capital Mobility

4.1 Introduction

> *"The recent economic crisis has no precedent in our generation. The steady gains in economic growth and job creation witnessed over the last decade have been wiped out – our GDP fell by 4% in 2009, our industrial production dropped back to the levels of the 1990s and 23 million people - or 10% of our active population - are now unemployed…"*
>
> European Commision (2010, p. 7)

The above statement is an extract from the *Europe 2020: A strategy for smart, sustainable and inclusive growth* regarding the recent economic crisis which began in 2007. A remarkable feature of that crisis is the dramatic collapse of international capital and trade flows. In 2008, global capital flow dropped by 16 percent – having attained a record high of approximately $2 trillion and accounting for over 16 percent of the world's gross fixed capital formation in 2007 – and additionally by 40 percent in 2009 (Poulsen & Hufbauer, 2011). At the same time, global trade contracted significantly, witnessing an unprecedented 30 percent decline between September 2008 and January 2009 (Bricongne, Fontagné, Gaulier, Taglioni, & Vicard, 2012).

The Gross Domestic Product (GDP) of individual countries were not left unaffected by these global developments. An example is the UK, whose GDP fell substantially by 7.2 percent between 2007 and 2009, of which about two-third of the decline is attributed to global shock – driven mostly by the collapse in foreign demand for UK's exports and export prices (Chowla et al., 2014). The contraction in the GDP was accompanied by deterioration in the labour market condition: vacancy creation rate fell by 5.6 percent between the first and second quarters of 2008, and by the first quarter of 2009, this had fallen further by 22 percent. Unemployment rate also rose by 1.3 percentage points to 7.1 percent between the third quarter of 2008 and the first quarter of 2009 (Clancy, 2009). These developments in the UK and elsewhere[1] spurred renewed interest in the literature regarding the effects of globalisation on the labour market. This chapter aims to contribute to this literature by investigating the dynamics of unemployment in a framework that integrates both international trade and capital mobility.

The literature on the labour market effects of international economic openness is large and varied. Here, we distinguish between two main strands of the literature relating to unemployment issues.[2] The first strand of this literature focuses on the consequences of

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[1] See Zmitrowicz and Khan (2014) for an assessment of labour market conditions in Canada and the United States during the economic crisis. Also see Salgado et al., (2014) for further evidence of the variations in the labour market responses following the crisis, and Jenkins, Brandolini, Micklewright, and Nolan, (2013) and Joyce and Sibieta (2013) for the distributional impact of the crisis on household income.

[2] For a recent survey of both theoretical and empirical effects of trade openness on unemployment see e.g. Belenkiy and Riker (2015) and the references therein. Also see Vallanti (2015) for the empirical study on capital mobility and unemployment. Yet. another strand of the literature focuses on the effects of international trade on wage – see Haskel, Lawrence, Leamer, and Slaughter (2012) for a review. An aspect of globalisation which has, to some extent,

international trade integration on the labour market as measured by changes in unemployment. Despite extensive research in this area, the exact impact of trade openness on unemployment remains inclusive. Dutt, Mitra, and Ranjan (2009) show that an increase in openness to trade which improves aggregate labour productivity will result in a lower unemployment. Cacciatore (2014) and Felbermayr et al. (2011) find a similar unemployment-reducing effect of trade, arguing that higher trade openness induces the reallocation of resources towards more productive firms, causing the larger and more profitable ones to select into exporting; thus, resulting in an economy-wide increase in average firms' productivity. A central message from these studies is that as long as a reduction in barriers to trade raises the (average) productivity of firms, and consequently, the marginal product of labour, it is likely to have an unemployment-reducing effect. By contrast, Cosar et al. (2016), Helpman and Itskhoki (2010) and Helpman, Itskhoki, and Redding (2010) show that while trade openness raises the profitability of exporting firms, it can lead to higher unemployment. Moore and Ranjan (2005) find an ambiguous effects of trade liberalisation on unemployment, but argue that such liberalisation can lead to an increase in the unemployment rate of unskilled workers.

The structure of the institutions governing the labour market are identified as playing an important role in determining the effects of trade integration on unemployment. In their static model with labour market frictions, Felbermayr et al. (2011) argue that wage setting mechanism is relevant for explaining the extent of effects of trade liberalisation: comparing both collective (unionised) and individual firm level wage bargaining solutions, they found that trade liberalisation results in a much lower unemployment in the latter. Cacciatore (2014) also shows that in the short run, the response of unemployment to trade openness is weakened in countries with high labour market rigidity. In the long run, however, countries with and without labour market frictions experience lower unemployment as a result of the opening to international trade. By contrast, Cosar et al. (2016) show that the unemployment-increasing effects of trade openness can be lowered via a simultaneous reduction in firing restrictions, measured by the firing cost incurred by firms upon job separation, and trade barriers. In their two-sector open economy model, Helpman and Itskhoki (2010) show that, through the reallocation of workers towards a more profitable exporting sector, trade integration can result in higher unemployment if this sector is to some extent characterised by greater labour market frictions.

The second strand of the literature, which has received considerably less attention, focuses on the labour market effects of international capital mobility. Rodrik (1998), one of the early authors who emphasised the link between international capital mobility and the labour market in a static partial equilibrium framework, shows that the degree of openness to capital mobility significantly affects the dynamics of the labour market. In particular, he demonstrates that lower barriers to international capital flow increases the volatility of wages and hours

also attracted attention in the literature is migration and its effects on the labour market (see, among others, Dustmann, Glitz, & Frattini, 2008).

worked in response to shocks. Using a one-sector equilibrium life-cycle framework characterised by search and matching frictions, Azariadis and Pissarides (2007) also show that perfect capital mobility increases the responsiveness of unemployment to domestic productivity shock. However, when compared to a closed economy setting, without access to international capital facilities, the effect is less persistent as the impact of shock dies out. Focusing on the structure of the labour market, Du et al. (2015) show that a lower restriction to capital movement induces the inflow of foreign capital into countries with higher flexible labour market (low vacancy creation cost), and thus leads to lower unemployment. A similar unemployment-reducing effect is found by Head and Smith (2004) who studied the implications of labour market rigidities (measured by changes in unemployment benefits insurance) for unemployment rates in a symmetric two-country model with search and matching frictional labour market. In particular, the authors conclude that the gap in the unemployment rate between two countries widens as capital mobility increases, with a less flexible labour market country experiencing a greater increase in unemployment rate.

The above contributions typically separate the effects of international trade and capital mobility on the labour market, which is *not warranted* when they are both identified as key drivers of globalisation (Greenaway & Nelson, 2001; Helpman & Itskhoki, 2010), important sources of heterogeneity across countries (Antràs & Caballero, 2009) and channels through which global shocks can be transmitted to the domestic economy (Chowla et al., 2014; Rodrik, 1998). Antràs and Caballero show that, in the presence of international capital mobility, trade liberalisation leads to capital outflow, which can potentially result in higher unemployment volatility (Azariadis & Pissarides, 2007). Egger, Greenaway, and Seidel (2011) also argue that while an increase in labour market rigidity leads to higher unemployment and lower trade flow, allowing for international capital mobility can reverse the latter effect.

Another common feature of the above studies is the emphasis on the ‘direct’ effects of economic openness (i.e. liberalisation). Little attention is paid to how the actual degree of openness of an economy drives its reaction to global and domestic economic shocks (e.g, in Cosar et al., 2016; Felbermayr et al., 2011; Helpman & Itskhoki, 2010). In the trade-unemployment literature, a notable exception is Cacciatore (2014), who shows that the degree of trade openness matters for the propagation of domestic shock. A recent survey of labour market responses to the last economic crsis by Salgado, Figari, Sutherland, and Tumino (2014) shows that wide variations persisted in many countries in the EU throughout the period of the crisis. Given the variation in the degree of economic openness from one country to another, the sensitivity of each to global economic developments – including those emerging from within – and their attendant consequences on the domestic economy is likely to depend on their extent of openness to the rest of the world. Gamberoni, Uexkull, and Weber (2010) show (empirically) that the contractionary effect of the last economic crisis on unemployment was higher in countries with greater openness to international trade. Additionally, in an empirical study which covered a panel of 20 OECD countries over a 30-year period, Vallanti (2015) found that greater exposure to international capital mobility increases unemployment fluctuations in response to aggregate shock.

This chapter develops a small open economy dynamic stochastic general equilibrium (DSGE) model in which unemployment arises due to search and matching frictions. An important departure from the literature is that we explicitly model an economy linked to the rest of the world through international trade and capital mobility. We are particularly interested in answering the following specific questions: first, what are the individual and combined effects of changes in the degree of openness to international trade and capital mobility on labour market outcomes, especially unemployment? Second, how does the degree of openness shape the transition path of unemployment in response to, e.g., domestic productivity and foreign demand shocks? Third, what are the individual and joint effects of labour market reforms – including active labour market policies (ALMPs) – and economic openness on unemployment? And, how do labour market reforms and ALMPs drive unemployment dynamic to openness shocks?

Our framework features a representative household, two vertically integrated production sectors (final and intermediate good sectors), a hiring sector, and a government. The household consumes, store its wealth in physical capital and supplies labour. To capture international capital mobility, the household is assumed to have access to international capital facilities which can be used to deal with the domestic residual capital requirement. Capital mobility involves transaction cost, which we model along the line proposed by Rodrik (1998). The intermediate good sector is characterised by monopolistic competition in its product market as governed by the horizontally differentiated nature of the varieties produced using capital and labour man-hours as factor inputs. Differentiated varieties are sold both domestically and as export. The final good sector, assumed to operate under perfect competition, produces a homogenous non-traded final good by aggregating domestic and imported differentiated varieties. Both exporting and importing activities are subject to iceberg-trade cost (e.g., see, Feenstra, Obstfeld, & Russ, 2014; Molana et al., 2016). The hiring sector is modelled – as in Christoffel and Kuester (2008) and de Walque, Pierrard, Sneessens, and Wouters (2009) – to act as an intermediary between the household that supplies labour and the intermediate sector that uses the service of labour as input. This sector is established by the government[3] that is also responsible for regulating policies governing the employment.

[3] A recent evaluation of private vs public recruitment agencies in the EU show that the former provides a much more effective service delivery in terms of number of workers who exit unemployment (Behaghel et al., 2014). Additionally, there is marked difference between the percentage of unemployed job seekers who use private and public recruitment agencies within the EU. As suggested by the European Labour Market Survey data, provided by the Eurostat, these differences ranges from approximately 25 percent and 53 percent in the UK to 8 percent and 70 percent in Sweden for private and public recruitment agencies respectively, between the first quarter of 2008 and third quarter of 2016. (The EU-27 average over this period is reported to be 22 percent and 53 percent.) Also note that allowing for direct matching between workers and firms will not change the qualitative effects of our results. In fact, as suggested by data, in the UK, Sweden and Germany, the percentages of workers who applied directly to employers between the first quarter of 2008 and third quarter of 2016 are respectively 1.3, 24.8 and 60.1 percentage point less that those who applied through public recruitment agencies. Source: http://ec.europa.eu/eurostat/web/lfs/data/database, [lfsq_ugmsw].

We calibrate the model so that its steady state can reflect the main empirical characteristics of the current UK economy, with particular focus on its long-run labour market features, and then examine both the steady state and the dynamic features of the model numerically. The key results are summarised as follows: first, we demonstrate that both international trade and capital mobility matter for the behaviour of unemployment. Both in the steady state and the dynamic short-run, a reduction in the barriers to capital mobility in *isolation* leads to lower unemployment. The intuition is that an increase in capital mobility signifies a rise in *investment opportunities*, due to lower transaction cost associated with the movement of capital across borders. All else equal, this incentivises the household to increase investment in capital. We identify two main channels through which this can impact unemployment, which we refer to as domestic *demand effect* and *wealth effect*. First, by raising investment drive, and thus capital, an increase in capital mobility, drives up the demand for domestic goods, which, in turn, leads to a rise in labour productivity. Higher labour productivity induces more recruitment in the hiring sector, leading to lower unemployment. Second, as domestic capital increases, the ensuing negative interest rate differential triggers capital outflow. Since this implies an increase in household's financial wealth via returns on net capital flow, consumption rises, further encouraging vacancy creation and employment. As for the effect of international trade, we find that a reduction in barriers to trade leads to lower unemployment through an increase in foreign demand for domestic export, which increases labour productivity, consistent with the literature. Our model predicts that, compared to individual cases, a joint reduction in capital mobility and trade barriers can deliver greater benefit in terms of lower unemployment.

Second, our results reveal that the degree of openness to trade and capital mobility is also crucial for determining how shocks – arising from both the domestic economy and the rest of the world – affect unemployment dynamics. More importantly, the ability of the economy to smooth out the effects of these shocks hinges on its degree of access to the international capital facility: a higher (lower) barrier to international capital facilities reduces (increases) the ability of the household to respond to shocks by either importing or exporting capital. The intuition is straightforward: suppose a positive productivity shock hits the domestic economy. This intensifies the demand for factor inputs (labour and capital) as well as raises the domestic rate of return on capital. With lower barriers to capital mobility, it is cheaper to import capital to support domestic production. The inflow of foreign capital, thus, enables firms to increase production, leading to a much lower unemployment, along the line predicted by Azariadis and Pissarides (2007). By contrast, if there is high barrier to international capital mobility, *agents are forced to formulate* investment *plans* in order to meet sudden changes in domestic capital requirements, which implies that investment and capital must rise in response to a positive productivity shock. Under this condition, the impact of the shock on unemployment depends on the degree of openness to international trade. If trade cost is relatively low, the positive productivity shock tends to produce a much larger reaction in unemployment than if there is higher trade barrier. A striking finding from this study is that shocks arising from different sources are likely to have different impact on the adjustment of unemployment, depending the degree of capital mobility. In particular, we find that while a lower barrier to capital mobility amplifies the response of unemployment to a positive productivity shock, it weakens the response to a positive foreign demand shock. By contrast, a reduction in trade cost amplifies the effect of both shocks on unemployment: both the speed of initial adjustment and the peak effects are enhanced.

Finally, this chapter illustrates the relevance of labour market policies in an economy with international openness. We find that whilst labour market reforms and ALMPs – through their effects on the cost of vacancy creation and labour cost to the hiring sector – lead to a lower unemployment, their individual effect on unemployment is enhanced when accompanied by a reduction in either trade or capital mobility barriers. More crucially, given the recent emphasis on reforms towards a more flexible labour market system,[4] we investigate how the *flexicurity* welfare system – which combines flexibility in hiring and firing rules, while providing social security for unemployed workers in terms of unemployment benefits – affects the adjustment of unemployment to shocks. We then compare the results with two other notable welfare systems: the *liberal* (e.g. the UK) system, characterised by low unemployment benefit and firing cost, and moderately high job creation cost; and the *Mediterranean* (e.g. Spanish) system which features high unemployment benefit, high vacancy creation cost, and high firing cost structure. Consistent with data evidence (as recently documented by, e.g., Andersen, 2012), our results show that labour markets which are to some extent characterised by higher flexibility (corresponding to flexicurity and liberal welfare systems) exhibit higher volatility in unemployment in response to shocks compared to the more rigid Mediterranean system that produces a much slower and more protracted response in unemployment.

Our study is closest to a recent contribution by Egger, Greenaway, and Seidel (2011) who study the implications of labour market imperfections for trade flow in a multi-country static model with trade and capital mobility. The current paper, however, differs from theirs in that we consider a dynamic model which allows us to not only investigate the interactions between labour market rigidity and economic openness, but also examine how various degrees of openness influence the dynamics of unemployment to international shocks. This paper is also close to Dix-Carneiro (2014), but in contrast to the author, we consider international (rather than sectoral) capital mobility and take up the issue of unemployment which is missing in that paper. In general, our paper complements those in trade-unemployment literature, as well as the literature focusing on the effects of capital mobility on unemployment. A key distinction between these papers and ours is that we integrate both trade and capital mobility in a unified framework. Moreover, most studies within trade-unemployment literature assume that labour is the only factor of production. However, illustrated by, e.g., Heer and Maußner (2010) and Monacelli,

[4] The rise in the integration of global economies raise the emphasis on welfare state reforms that aim to increase the flexibility of firms in order to reduce the impact of globalisation on unemployment (see, e.g., Eurofound, 2007; European Commision, 2010).

Perotti, and Trigari (2010)[5] capital provides an additional channel for shock propagation.

The remainder of this study is structured as follows. In section 4.2, we formulate the model used for the analyses in this chapter, with details of equilibrium and market clearing conditions highlighted in section 4.3. The model calibration and details of our findings are discussed in sections 4.4, 4.5 and 4.6. Section 4.7 summarises and concludes this chapter.

4.2 The Model

This section develops a small open economy DSGE model characterised by households, two production sectors, a hiring sector, and a government. We adopt the representative household construct of Andolfatto (1996) and Merz (1995), which supplies labour, consumes final good and invests in capital. The latter serves a dual function as a productive factor and as a store of wealth and is assumed to be internationally mobile. We model a competitive final good sector that produces a non-traded homogenous final good using both imported and domestic differentiated varieties as inputs.[6] Differentiated varieties are produced using both labour and capital as factor inputs by an intermediate sector that faces monopolistic competition in the products market. These varieties are traded domestically and internationally. Both international trade in goods and capital movement are respectively subject to iceberg trade cost (e.g., Molana et al., 2017; Feenstra, Obstfeld, & Russ, 2014) and capital mobility transaction cost (e.g. Rodirk,1998). The 'small' open economy assumption implies that activities of domestic agents cannot influence the foreign demand for domestic exports, the price of imported varieties, and the world rate of return on capital. The hiring sector is characterised by search and matching frictions and acts as an intermediary between household members searching for jobs and the intermediate sector that uses the services of these workers (similar to Christoffel, Kuester, & Linzert, 2009; de Walque, Pierrard, Sneessens, & Wouters, 2009). The sole function of this sector is to hire and train unemployed workers and sell their services as trained man-hours. We assume that employment relationships are destroyed at an exogenous rate, and wages and hours worked per worker are determined via Nash bargaining solution. There is a government that sets employment policies and is assumed to own the hiring sector. The government operates a balanced budget and uses net revenue generated from the operation of the hiring sector as well as lump-sum tax to finance social benefits provided to the unemployed.

4.2.1 The Representative Household

Consider an economy consisting of a representative household with a unit measure of members,

[5] Both authors study the role of labour market frictions for the transmission of shocks with a closed economy environment.

[6] Our approach is motivated by the increasing evidence of international production fragmentation, where firms are able to source intermediate goods from different countries (Foster, Stehrer, & Timmer, 2013). Additionally, as revealed by Sébastien, Lanz, and Ragoussis (2009), trade in intermediate input accounts for approximately 56 percent trade flow in most developed countries.

who are either employed or unemployed at any given time. At time *t*, a share N_t of the household members are employed by the labour market hiring firms while the rest are unemployed. The latter consists of workers who were not at all employed in the previous period $(1-N_{t-1})$ and those who were employed but lost their job at the end of period $t-1$, ηN_{t-1}, where $\eta \in (0,1)$ denotes the rate of job destruction assumed to be exogenous as in Hall (2005) and Blanchard and Galí (2010).[7] Hence, by normalising the labour force to the size of representative household, the aggregate number of members who are unemployed – and searching for job – in the household, at time *t*, is given by $U_t = 1-(1-\eta)N_{t-1}$. We assume that members of the household completely insure each other against uncertainty in earnings and unemployment risks in line with the literature.[8] The objective of the representative household, assumed to have an infinite lifespan, is to maximise an expected lifetime utility function, which takes the form

$$E_t \sum_{s=0}^{\infty} \beta^s \left[\frac{\xi_{ct+s} C_{t+s}^{1-\alpha_c}}{1-\alpha_c} - A \int_0^1 \frac{n_{jt+s} h_{jt+s}^{1+\alpha_h}}{1+\alpha_h} dj \right], \tag{1}$$

where $\beta \in (0,1)$ and $A > 0$ represent the household's subjective discount factor and a measure of the disutility of working, respectively. ξ_c captures consumption preference shock (e.g. Christoffel et al., 2008), and $0 < \alpha_c \leq 1$ and $\alpha_h > 0$ determine, respectively, the intertemporal elasticity of substitution and the Frisch elasticity of labour supply. As will be explained below in more detail, there is a sector in the economy which fulfils the exclusive, and intermediary, role of recruiting and training workers and selling services of trained workers as labour man-hours. The sector is populated by a mass of 'labour hiring firms' which is normalised to unity with the firms indexed by $j \in (0,1)$. Based on this structure, n_{jt+s} and h_{jt+s} in the utility function denote the number of household members employed by firm *j* at time $t+s$ and the respective labour supply of these members.

The household uses physical capital to store its wealth and at any time $t+s$ it faces two intertemporal constraints: the budget constraint

$$\begin{aligned} C_{t+s} + I_{t+s} + r_{t+s}^{*}\left(M_{t+s}k_{t+s} - K_{t+s}\right) = \\ \int_0^1 w_{jt+s} n_{jt+s} h_{jt+s} dj + (1-N_{t+s}) b_{t+s} + M_{t+s}\pi_{t+s} + r_{t+s} M_{t+s} k_{t+s} - T_{t+s}, \end{aligned} \tag{2}$$

and the capital accumulation constraint

$$K_{t+s+1} = I_{t+s} + (1-\delta) K_{t+s}, \tag{3}$$

where *C*, *I*, *K* and π represent the real values of consumption, investment, capital stock and profit

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[7] Hall (2005) document that a large percentage of the variation of employment over the business cycle is explained by variations in vacancy creation rather than the job separation rate. For simplicity, we therefore assume that job separations are exogenous in this model.

[8] See, Andolfatto (1996) and Merz (1995).

from each intermediate firm (explained later), respectively. The variables r_t and w_t denote the gross domestic real return rate on capital held during time *t* and the real hourly wage rate, respectively. The members of the household who remain unemployed after hiring has taken place at time *t*, receive an unemployment benefit, b_t, thereby attracting $(1-N_t)b_t$ to the household. The stock of capital is assumed to depreciate at a constant rate δ, and T_t is a lump-sum tax paid to the government.

As we will later explain in more detail, there also exist a sector in the economy populated with monopolistic firms. Each of these firms is assumed to produce a single variety – indexed by $i \in M_t$ – of intermediate good, using k_{it} capital stock rented from the household as one of its input required for production. Thus, at time $t+s$, the aggregate capital required by these firms is given by $M_{t+s}k_{t+s}$, which then attracts an aggregate capital income, $r_{t+s}M_{t+s}k_{t+s}$, to the household. We assume the availability of international capital mobility facility which the household can access to deal with any residual capital requirement $(M_{t+s}k_{t+s} - K_{t+s})$. This assumption implies that the household can borrow from abroad (or lend abroad), at a foreign real rate of return on capital, r^*, when $(M_{t+s}k_{t+s} - K_{t+s}) > 0$ (< 0). Letting $\kappa \geq 0$ denote a measure of the degree of capital mobility, as in Rodrik (1998), the capital market condition can be written as

$$r_{t+s} = r_{t+s}^* + \kappa_{t+s}\left(M_{t+s}k_{t+s} - K_{t+s}\right). \tag{4}$$

In line with our small open economy assumption r_t^* is exogenous and cannot be influenced by the activities in the domestic economy. Thus, condition (4) implies that, at any given time t, an increase in the demand for capital in excess of its supply, i.e. $M_tk_t > K_t$, requires that the domestic return rate on capital r_t must rise above r_t^* in order for the equilibrium condition (4) to be restored, for a given value of κ_t. Intuitively, if domestic demand for capital rises above what the economy can supply, then to attract foreign capital, the domestic return rate of capital r_t must rise in order to cover foreign interest on capital r_t^* plus the margin associated with the cost importing from abroad $\kappa_t\left(M_tk_t - K_t\right)$. Note that $\kappa_t = 0$ is consistent with $r_t = r_t^*$ and corresponds to perfect mobility, while $\kappa_t \to \infty$ corresponds to the case of no mobility, and $M_tk_t = K_t$ holds for any $\left(r_t - r_t^*\right) = 0$.

The household's problem is to choose the optimal paths of consumption and capital stock $\left\{C_{t+s}, K_{t+s+1}\right\}_{s=0}^{\infty}$ in order to maximise the utility function (1) subject to the budget constraint (2) and the law of motion for capital (3), taking into consideration the condition (4) which governs the capital market and treating as given: the policy instruments $\left\{T_{t+s}, b_{t+s}\right\}_{s=0}^{\infty}$; the aggregate profits received from firms $\{\Pi_{t+s}\}_{s=0}^{\infty}$; the real interest rates $\{r_{t+s}, r_{t+s}^{*}\}_{s=0}^{\infty}$; the hourly real wage per worker and hours supplied per worker $\{w_{t+s}, h_{t+s}\}_{s=0}^{\infty}$; and the initial condition for capital, K_0.[9] Letting the Lagrange multiplier associated with the household's budget constraint be Λ_t, the first order conditions resulting from maximisation, for $s=0$, are given by[10]

$$\Lambda_t = \xi_{ct} C_t^{-\alpha_c}, \tag{5}$$

$$\Lambda_t = \beta E_t \left[\Lambda_{t+1} \left(1 - \delta + r_{t+1}^{*} - \kappa_{t+1} M_{t+1} k_{t+1} \right) \right]. \tag{6}$$

Equations (5) and (6) respectively describe the representative household's marginal utility of consumption and the Euler condition governing the optimal consumption path. For later use, we define $R_{t+s} \equiv \left(1 - \delta + r_{t+s+1}^{*} - \kappa_{t+s+1} M_{t+s+1} k_{t+s+1}\right)$ and rewrite the Euler condition (6) as $1 = E_t\left[\Omega_{t+s} R_{t+s}\right]$, where

$$\Omega_{t+s} = \beta \prod_{j=1}^{s} \left(\frac{\Lambda_{t+j}}{\Lambda_{t+j-1}} \right) \equiv \beta \left(\frac{\Lambda_{t+s}}{\Lambda_t} \right), \tag{7}$$

denotes the *stochastic discount factor*, governing the rate at which the household is willing to substitute consumption between time t and $t+s$.

4.2.2 The Final Good Sector

The modelling of the final good sector follows Molana and Montagna (2000). This sector is represented by a single firm which operates under a perfectly competitive structure, and produces a homogeneous final good, Y, used by the households for consumption and for investment. We assume that the production technology of this sector is a CES function which combines quantities of domestically produced and imported intermediate varieties, y_{it}^{d} and y_{it}^{*}, respectively, according to

$$Y_t = \left(M_t^{\frac{\lambda-1}{\sigma}} \int_{i \in M_t} \left(y_{it}^{d}\right)^{1-1/\sigma} di + M_t^{*\,\frac{\lambda-1}{\sigma}} \int_{i \in M_t^{*}} \left(y_{it}^{*}\right)^{1-1/\sigma} di \right)^{\frac{1}{1-1/\sigma}}, \tag{8}$$

where the superscript * refers to foreign variables, M and M^{*} denote mass of available varieties both in the domestic and foreign economies. The parameter $0 \le \lambda \le 1$ determines the degree of importance attached to 'the number of varieties', where $\lambda = 0$ and $\lambda = 1$ respectively corresponds to the two extreme cases of 'no effect' and 'maximum effect'. When $\lambda > 0$, an increase in M – for given quantities of the individual inputs – results in a higher output.[11] The parameter $\sigma > 1$ is the elasticity of substitution between input varieties, which is assumed to be equal across

[9] Both the real wage and hours of work are determined jointly by firms and workers in the labour market, which we will discuss later in the paper.

[10] See Appendix 4 for the details of this, and other, derivations.

[11] For details, see Benassy (1996) and Molana and Montagna (2000).

countries. The sector's profit is defined by

$$\Pi_{Yt} = P_t Y_t - \left(\int_{i \in M_t} p_{it}^d y_{it}^d di \ + \int_{i \in M_t^*} \tau_t p_{it}^* y_{it}^* di \right), \tag{9}$$

where p_{it}^d and p_{it}^* are the prices of intermediate varieties produced domestically and imported and $\tau \geq 1$ denotes per-unit *iceberg* trade cost incurred in importing foreign intermediate varieties. The iceberg specification of the trade cost implies that to one unit of the good abroad a firm needs to ship $\tau \geq 1$ units of the good (i.e., a proportion $(1-1/\tau)$ melts in transport and a proportion $1/\tau$ arrives at destination) – similar to Feenstra et al. (2014) and Ghironi and Melitz (2005).

Maximising (9) subject to (8), taking all prices and the trade cost as given, we derive the demand functions for domestic and foreign intermediate varieties,

$$y_{it}^d = M_t^{\lambda-1} Y_t \left(\frac{p_{it}^d}{P_t} \right)^{-\sigma}, i \in M_t, \tag{10}$$

and

$$y_{it}^* = M_t^{*\lambda-1} Y_t \left(\frac{\tau_t p_{it}^*}{P_t} \right)^{-\sigma}, i \in M_t^*. \tag{11}$$

The perfect competition assumption requires $\Pi_{Yt} = 0$. Therefore, using this assumption, the domestic price index dual to (8) can be shown to satisfy

$$P_t = \left(M_t^{\lambda-1} \int_{i \in M_t} \left(p_{it}^d \right)^{1-\sigma} di + M_t^{*\lambda-1} \int_{i \in M_t^*} \left(\tau_t p_{it}^* \right)^{1-\sigma} di \right)^{\frac{1}{1-\sigma}}. \tag{12}$$

4.2.3 Export (Foreign Demand)

We assume that an endogenous quantity of the domestically produced intermediate variety is exported abroad at a nominal price p_{it}^d. However, given the existence of iceberg trade cost, foreign buyers are faced with an effective real price $\left(\tau_t p_{it}^d / P_t^*\right)$ per unit of exported variety, where P^* denotes foreign price index. Letting F^* denote the real foreign expenditure on exported varieties, and assuming that the demand elasticity is equal across countries, the foreign demand function for domestically produce intermediate variety can be written as

$$y_{it}^x = M_t^{\lambda-1} F_t^* \left(\frac{\tau_t p_{it}^d}{P_t^*} \right)^{-\sigma}, \ i \in M_t, \tag{13}$$

where y_{it}^x represents the quantity of domestic variety that is exported. Again, by virtue of the small open economy assumption, F^* and P^* are unaffected by the developments in the domestic economy, so they are treated as exogenous variables.

4.2.4 The Intermediate Sector

The intermediate goods sector comprises of a mass *M* of monopolistically competitive firms. Each firm produces a single intermediate variety *i*, which is subsequently sold domestically as input to the final good sector and as export, with demand functions respectively given by (10) and (13). Thus, at any given time the aggregate quantity of variety *i* produced by a typical intermediate firm is defined as

$$z_{it} = y_{it}^{d} + \tau_t y_{it}^{x}. \tag{14}$$

Each variety is produced using a composite of Cobb-Douglas input comprising of two factors: capital, which is rented from the household at a price r_t per unit of capital, and effective labour man-hours, purchased from the hiring sector at a price $\tilde{w}_t$ per effective labour man-hour. Defining a_{it} as the composite input, and using l_{it} and k_{it} to denote the quantities of man-hours and capital, respectively, we assume that

$$a_{it} = \left(\frac{l_{it}}{\gamma}\right)^{\gamma} \left(\frac{k_{it}}{1-\gamma}\right)^{1-\gamma}, \tag{15}$$

where $\gamma \in [0,1]$ represents the elasticity of output with respect to labour man-hours input. The production function of each firm is then described by its input requirement, which is assumed to be linear and given by

$$z_{it} = \varphi_t a_{it}, \tag{16}$$

where φ_t represents productivity factor, assumed to be common to all firms and to vary exogenously over time. At any given time t, the real profit function of each firm is described by

$$\pi_{it} = \left(\frac{p_{it}^{d}}{P_t}\right) z_{it} - p_{at} a_{it}, \tag{17}$$

where p_{at} represents the unit cost of production and $p_{at} a_{it}$ denotes the firm's real total cost of production at time *t*, which in turn is defined – based on the firm's input requirement – as

$$p_{at} a_{it} = \tilde{w}_t l_{it} + r_t k_{it}. \tag{18}$$

Using the production function (15) together with the total cost function (18) we obtain the cost minimising price level for factor input as

$$p_{at} = r_t^{(1-\gamma)} \tilde{w}_t^{\gamma}, \tag{19}$$

which corresponds to the real marginal cost of production. Both prices, r_t and $\tilde{w}_t$, are taken as given by each firm, thus making p_{at} independent of individual firm's characteristics. Applying Shephard's lemma to (18), we derive the respective optimal demand functions for each factor input

$$\tilde{w}_t l_{it} = \gamma p_{at} \frac{z_{it}}{\varphi_t} \tag{20}$$

and

$$r_t k_{it} = (1-\gamma)\, p_{at} \frac{z_{it}}{\varphi_t}. \tag{21}$$

Finally, given the assumption of monopolistic competition, each firm chooses its own optimal price p_{it}^d which maximise the profit function (17) subject to its product demand functions, (10) and (13). The first order condition with respect to p_{it}^d yields

$$\frac{p_{it}^d}{P_t} = \frac{\sigma p_{at}}{(\sigma-1)\varphi_t}, \tag{22}$$

which represents the standard flexible mark-up pricing rule. The above equation shows that, in the absence of price setting frictions,[12] each firm simply sets its price as a mark-up over the real marginal cost.

4.2.5 Hiring Sector (The Labour Market)

We model the labour market by introducing a sector which consists of hiring firms set up by the government to serve as intermediary between members of the household who supply labour and intermediate firms that demand labour (as in Christoffel & Kuester 2008; de Walque et al. 2009; Di-Pace & Hertweck, 2012). The main function of the firms in this sector is to hire and train unemployed members of the household and sell the labour service of trained workers as effective man-hours. Recall that when describing household's preferences, we normalised the mass of labour hiring firms to unity, indexed firms by $j \in [0,1]$ and assumed that at any time *t*, a firm *j* hires n_{jt} members of the household as workers who supply h_{jt} hours of work each at an hourly real wage of w_{jt} in order to produce effective labour man-hours. We further assumed that each worker's labour supply is converted to effective man-hours using a concave conversion technology[13]

$$\tilde{h}_{jt} = \frac{e_t}{\alpha_f} h_{jt}^{\alpha_f}, \; 0 < \alpha_f < 1, \tag{23}$$

where $e_t > 0$ is a measure of effort, determined exogenously. The aggregate supply of the sector, $\int_0^1 n_{jt}\tilde{h}_{jt}dj$, is then offered to the intermediate good producing sector, whose aggregate demand is $\int_{i\in M} l_{it}di$ – at the real rate $\tilde{w}_t$.

[12] In the models with price setting frictions, such as the Calvo (1983) type friction, a fraction of firms is assumed to optimally reset their prices in each period while the remaining fraction do not. The former simply update their prices based on a rule of thumb approach which is (commonly) based either on: (1) the most recently observed inflation and price level, (2) steady state inflation and most recently observed price level, or (3) simply on most recently observed price (McCandless, 2008). In the current model we assume full price flexibility – see Gali (2008) for details.

[13] In particular, we require this assumption in order to derive work optimal hours (de Walque et al., 2009).

The labour market is assumed to be characterised by search and matching frictions. The matching process between the firms with vacancies and searching unemployed workers is governed by a matching technology which at the aggregate level is assumed to take the form

$$\mathfrak{M}\left(U_t, V_t\right) = \chi U_t^{\mu} V_t^{1-\mu}\,,\ \chi > 0\,,\ 0 < \mu > 0\,, \tag{24}$$

where $U_t = 1 - \left(1-\eta\right) N_{t-1}$ and $V_t = \int_0^1 v_{jt} dj$ denote aggregate unemployment and vacancies, respectively, χ is a measure of matching efficiency and μ is the elasticity of match with respect to *U*. We further define

$$\theta_t = \frac{V_t}{U_t}\,, \tag{25}$$

as a measure of 'the degree of market tightness'. Using (24), the rates at which a firm with vacancy meets an unemployed worker (vacancy filling rate) and that an unemployed worker meets a vacant job (job finding rate) are, respectively, defined by

$$q_t^f = \frac{\mathfrak{M}\left(U_t, V_t\right)}{V_t} = \chi \left(\frac{V_t}{U_t}\right)^{-\mu} = \chi \theta_t^{-\mu}\,, \tag{26}$$

and

$$q_t^w = \frac{\mathfrak{M}\left(U_t, V_t\right)}{V_t} = \chi \left(\frac{V_t}{U_t}\right)^{1-\mu} = \chi \theta_t^{1-\mu}\,. \tag{27}$$

Given the homogeneity assumption of the matching function, both vacancy filling and job finding rates depend solely on the degree of market tightness: a rise in θ_t raises the job finding rate and reduces the vacancy filling rate, and vice versa. Therefore, $1/q_t^f$ and $1/q_t^w$ respectively represent the mean duration of vacancies and unemployment spell.
At each hiring firm's level, aggregate employment evolves according to

$$n_{jt} = \left(1-\eta\right) n_{jt-1} + q_t^f v_{jt}\,, \tag{28}$$

where $\left(1-\eta\right) n_{jt-1}$ and $q_t^f v_{jt}$ respectively measure the number of jobs that survived separation from the previous period $t-1$ and the new matches at period t in firm *j*. Thus, in line with Blanchard and Gali (2010) and Faccini et al. (2013), the timing convention in (28) implies that newly matched workers become productive immediately after being matched with a vacancy.

We follow the literature (e.g., Faccini, et al., 2013; Ravenna & Walsh, 2012; Trigari, 2006) in modelling the bargaining process between workers and hiring firms that determine w_{jt} and h_{jt} and therefore assume that the outcome of the bargain maximises value of the mutual surplus of the resulting match.

To hire new workers, at any time t each firm creates v_{jt} vacancies. In particular, the objective of each firm at any $t+s$ is to choose the optimal number of vacancies v_{jt+s} and employees n_{jt+s}, which maximise its present discounted value of real expected profit

$$\Pi_{jt}^{L} = E_t \sum_{s=0}^{\infty} \Omega_{t+s} \left[n_{jt+s} \left(\tilde{w}_{t+s} \tilde{h}_{jt+s} - w_{jt+s} h_{jt+s} - \left(1-\zeta_{t+s}^{T}\right) x^{T} - \eta f_{t+s} \right) - \left(1-\zeta_{t+s}^{V}\right) x^{V} v_{jt+s} \right], \tag{29}$$

where x^T and x^V are per capita worker training cost training cost (e.g. Ljungqvist & Sargent, 2016; Pissarides, 2009; Stähler & Thomas, 2012) and vacancy creation/posting costs incurred by the firm, which are assumed to be time-invariant. Firms are further assumed to receive subsidies from the government, ζ_t^T and ζ_t^V, for each worker it hires (a per capita training subsidy) and each vacancy it creates.[14] Also, we have assumed that job destruction is costly and denote by f_t the associated per capita firing cost. In maximising (29), the firm treats Ω_{t+s}, w_{jt+s}, $\tilde{w}_{t+s}$, h_{jt+s}, ζ_{t+s}^{T}, ζ_{t+s}^{V} and x^T and x^V as given and takes account of (7), (23) and the path in (28). Denoting by J_{jt} the Lagrange multiplier associated with the constraint (28), the first order conditions with respect to v_{jt} and n_{jt}, for $s = 0$, respectively yield[15]

$$\frac{\left(1-\zeta_t^{V}\right) x^{V}}{q_t^{f}} = J_{jt} \tag{30}$$

and

$$J_{jt} = \tilde{w}_t \tilde{h}_{jt} - w_{jt} h_{jt} - \left(1-\zeta_t^{T}\right) x^{T} - \eta f_t + (1-\eta) E_t \Omega_{t+s} J_{jt+1}. \tag{31}$$

Equation (30) shows that the marginal cost of creating a vacancy must be equal to the value of the corresponding contribution resulting from hiring an additional worker to the firm, which is in turn defined by the right-hand-side of (31). Combining both (30) and (31) yields

$$\frac{\left(1-\zeta_t^{V}\right) x^{V}}{q_t^{f}} = \tilde{w}_t \tilde{h}_{jt} - w_{jt} h_{jt} - \left(1-\zeta_t^{T}\right) x^{T} - \eta f_t + (1-\eta) E_t \Omega_{t+s} \frac{\left(1-\zeta_{t+1}^{V}\right) x^{V}}{q_{t+1}^{f}}, \tag{32}$$

which represents the usual vacancy creation condition consistent with that proposed in the literature – see Pissarides (2000) for an example. Equation (32) simply states that, at any given time period, each firm creates vacancies up to a point where the marginal contribution of an additional worker to the firm (right-hand-side) equals the marginal hiring or vacancy creation costs (left-hand-side).

From the perspective of the household, the marginal value of having one of its members hired at firm *j* is given by value equation

[14] These forms of subsidies were granted during the last recession by some countries. For instance, in order to combat the effects of the last (2007/2008) recession on unemployment, the UK government provided £350 million to small and medium scale businesses to enable them train employees (Heyes, 2013). According to Heyes (2013), in Ireland, the government also introduced employment subsidy per hired worker and subsidies which enable firms to hire up to certain number of workers.

[15] See Appendix 4 for the derivation.

$$W_{jt}=w_{jt}h_{jt}-\left[b_t+\frac{Ah_{jt}^{1+\alpha_h}}{\Lambda_t\left(1+\alpha_h\right)}\right]+\left(1-\eta\right)E_t\Omega_{t+s}\left[1-q_{t+1}^{w}\right]W_{jt+1}. \tag{33}$$

Equation (33) shows that the return from being employed at each hiring firm consists of the real wage income $w_{jt}h_{jt}$ less the value of his outside option – the term in the squared brackets on the right-hand-side which is increasing in the value of unemployment benefit and the worker's disutility of supplying labour hours – and the continuation value of employment if the match remains unseparated with a probability $\left(1-\eta\right)$.

Letting $\Phi\in\left[0,1\right]$ denote the relative bargaining power of a worker, the solutions to the bargaining problem are given by the real hourly wage rate and hours of work which maximises the weighted product of the interested parties' surplus shares, $J_{jt}^{(1-\Phi)}W_{jt}^{\Phi}$. The first order condition of this maximisation problem with respect to w_{jt} yields

$$\Phi J_{jt}=\left(1-\Phi\right)W_{jt}. \tag{34}$$

Using equations (31) and (33), we eliminate J_{jt} and W_{jt} from equation (34) to obtain the solution for the bargained real wage

$$\begin{aligned} w_{jt}h_{jt} &= \Phi\left\{\tilde{w}_t\tilde{h}_{jt}-\left(1-\zeta_t^{T}\right)x^{T}-\eta f_t+\left(1-\eta\right)E_t\Omega_{t+s}\left(1-\zeta_{t+1}^{V}\right)x^{v}\theta_{t+1}\right\} \\ &\quad+\left(1-\Phi\right)\left\{b_t+\frac{Ah_{jt}^{1+\alpha_h}}{\Lambda_t\left(1+\alpha_h\right)}\right\}. \end{aligned} \tag{35}$$

As shown by equation (35), the real wage income of a worker at firm *j* is given by the weighted sum of the match productivity net of the per capita training and firing costs and the replacement cost of the worker, and the outside option of the worker, where the weights are respectively given by Φ and $\left(1-\Phi\right)$. Note that in the absence of training and firing costs and employment subsidies, i.e., $\left(x^{T},f,\zeta^{V},\zeta^{T}\right)=0$, equation (35) collapses to the standard wage equation commonly found in the literature. However, as can be seen, the training and training and vacancy creation subsidies, ζ^T and ζ^V, have some interesting implications for the labour market dynamics through the wage equation. A higher training cost leads to lower real wage because, by increasing the cost of match, it reduces the value of a filled vacancy *J*. Intuitively, because a lower *J* implies that only a limited number of vacancies are created by firms, which in turn leads to higher aggregate unemployment, unemployed workers are inclined to accepting lower wage in order to become trained and employed. However, if the government provides training subsidy to the firm towards the worker's training, the overall labour cost reduces, and so the real wage rises. The impact of vacancy creation subsidy, ζ^V, on the real wage depends on its affects job creation rate and, in turn, the market tightness, θ. In particular, given that the hiring need of a firm reduces when a given match survives exogenous separation at a rate, $\left(1-\eta\right)$, by raising θ, an expected increase in ζ^V will lead to a rise in the savings associated with the replacement costs of a worker. All else equal, the bargained real wage will increase as workers share from this savings (see Pissarises, 2000)

Finally, the first order condition of the bargaining process with respect to h_{jt} can be shown satisfy

$$\frac{Ah_{jt}^{\alpha_h}}{\Lambda_t} = e_t \tilde{w}_t h_{jt}^{\alpha_f - 1}. \tag{36}$$

This equation implies the optimal hours of work is determined such that the marginal product of hours is equal to the marginal rate of substitution between consumption and leisure.[16]

4.2.6 The Government

As already noted, the government supports unemployed workers through the provision of benefit insurance, and provides employment enhancing subsidies towards vacancy creation and training costs for the hiring sector. These are in turn financed by revenues accrued from the hiring sector's operation, lump-sum and firing taxes. Thus, per period budget constrain of the government satisfies[17]

$$T_t + N_t\left(\tilde{w}_t \tilde{h}_t - w_t h_t - x^T\right) - x^V V_t = \left(1 - N_t\right) b_t. \tag{37}$$

The government is assumed to run a balanced budget each period, where lump-sum tax T is allowed to adjust at all times to ensure that this holds.

4.3 Market Clearing Conditions and General Equilibrium

We consider a symmetric equilibrium where firms behave identically. Therefore, we drop the firm indices *i* and *j*, and express the equilibrium conditions in terms of the values pertaining to the representative firm/variety.

Equilibrium in the labour market requires that aggregate effective labour man-hours supplied at any given time must be equal to its demand,

$$\int_0^1 n_{jt} \tilde{h}_{jt} dj = \int_0^M l_{it} di \Rightarrow N_t \tilde{h}_t = M_t l_t. \tag{38}$$

Also, the good market clearing condition requires that

$$Y_t = C_t + I_t + x^T N_t + x^V V_t. \tag{39}$$

Thus, as in Christoffel et al. (2008), Y also covers labour training and vacancy creation costs, in addition to its use for household consumption and investment purpose

In the equilibrium, the balance of payment – which must be satisfied when all the market clearing conditions and budget constraints hold – is determined by

[16] For details, see Trigari (2006).

[17] The per period profit from the hiring sector is accrued to the government since this sector acts as government subsidiary. Christoffel et al. (2008) for instance assumes that it goes to the household. In general, either of these assumptions is required to ensures that the goods market clearing condition holds.

$$M_t\left(\frac{\tau_t p_t^d}{P_t}\right)y_t^x - M_t^*\left(\frac{\tau_t p_t^*}{P_t}\right)y_t^* = r_t^*\left(M_t k_t - K_t\right). \tag{40}$$

Equation (40) shows that trade balance (or net export) must be equal to return on net capital flow to ensure that a zero balance of payment holds in equilibrium. Finally, the gross domestic product (*GDP*) can be shown to be equal to total domestic demand (39) plus net export:

$$GDP = Y_t + M\left(\frac{p_t^d}{P_t}\right)\tau_t y_t^x - M_t^*\tau_t\left(\frac{p_t^*}{P_t}\right)y_t^* \; . \tag{41}$$

The equation system characterising model economy, together with their steady state and linearized versions, are given in Appendix 4.

4.4 Model Calibration

As already indicated in the introduction the parameters of this model are calibrated so that the steady state solution replicates the structural features of the UK economy in the recent years. In doing this we use long-run data averages as well as empirical evidence, and the frequency of calibration is quarterly. In the absence of data or empirical evidence, we use the parameter and steady state values commonly used in the literature; where possible, those that focus on the EU. Table 4.1 in Appendix 4 provides the details of the model calibration.

Consistent with the literature (for instance, Harrison & Oomen, 2010), we set the depreciation rate of capital, δ, to 0.025, which implies an average annual capital depreciation rate of 10 percent. The actual estimate of the coefficient of relative risk aversion, α_c, that determines the utility of consumption, is still contested in the literature. As documented by Gandelman and Hernández-Murillo (2014) the estimated value of α_c typically ranges from 0.2 to 10. In our baseline calibration we set α_c to 0.8, which is close to the 0.73 estimated by Faccini et al. (2013), and falls between 0.143 and 1.03 estimated by Harrison and Oomen (2010) and Gandelman and Hernandez-Murillo (2015), respectively, for the UK. The baseline value of α_h is set to 2, an approximate value chosen by Faccini et al. (2013) for the UK and Christoffel et al. (2008) in a study relating to the EURO Area. The steady state values of the measure of foreign expenditure on exported varieties, $F^*$and foreign price index, P^*, are normalised to unity. The preference shock is assumed to be zero in the steady state, and hence ξ_c too is set to unity. We further assume that, in the steady state, aggregate domestic demand for capital equals its supply, $Mk = K$, which is consistent with $r = r^*$; hence, we set $r = r^* = 0.035$. The measure of the importance of varieties in the production of final good, λ, is set to zero – hence assuming away any 'variety externality' from the benchmark calibration. We follow Ghironi and Melitz, (2005) and set the initial value of the ice-berg trade cost, τ to 1.3.

As already noted, the steady state gross domestic product is given by $GDP = Y + \dfrac{Mp^d\tau y^x}{P} - \dfrac{M^*\tau p^* y^*}{P}$. As is common in the literature, e.g. Christoffel and Kuester

(2008), we normalise the GDP to unity. Since international flow of capital is zero in the initial steady state, trade balance too is zero, by virtue of equation (40). It follows that $GDP = Y$. The standard calibrated value of the elasticity of demand for differentiated varieties, σ, in the literature typically varies from 6 to 11 – for instance, Villa and Yang (2011) and Faccini et al. (2013) for the case of the UK. In our calibration we set the value of σ so that the share of total profit income in output in our baseline solution matches the long run data average, which is approximately 20 percent based on the UK quarterly data from 2000: Q1 to 2014: Q3 (ONS Statistics database). From the steady state version of our model, it can be shown that the ratio of total profit to aggregate domestic product is given by $M\pi/GDP=1/\sigma$. We therefore set σ to 6 – which also implies a monopolistic price mark-up of 20 percent.

As documented by Hobijn and Sahin (2009), in an empirical study which covers 27 OECD countries, the average (quarterly) value of q^w is 0.3381 in the UK. (We use this estimate to derive job destruction rate η below.) As noted previously, the size of the labour force is normalised to one. Using the harmonised quarterly unemployment rate data from 1986: Q2 to 2014: Q4, provided by the OECD, we obtain the employment rate, N, which equals 0.93 for the UK. Given the calibrated values of N and q^w, the steady state job destruction rate can be obtained using $\eta = \left(q^w(1-N)\right)\big/\left((1-q^w)N\right)$ as approximately equal to 0.038. Furthermore, we set the initial value of vacancy filling rate q^f is set to 0.7, the EU average as documented by Christoffel and Kuester (2008), and then allow vacancy creation cost x^V and per capita job training cost x^T to be residually derived from the steady state of the model to ensure that the targeted values of the labour market variables are achieved.

The presence of matching friction as well as the assumption of wage bargain in the model implies that the contribution of labour in the Cobb-Douglas input basket is not equal to the share of labour Nwh/GDP in the model. The data obtained from the ONS reveals that the average quarterly labour share between 1980: Q1 and 2014: Q4 in the UK equals 0.57. To capture this fact, we calibrate γ so that it produces Nwh/GDP observed in the data. This requires setting γ to approximately 0.7144. We use the OECD data on the total hours of work supplied per employed worker per year to obtain the calibration consistent with h in our model. The data shows that, on the average, the total number of work hours supplied per worker between 1990 and 2014 is 1,695 per year in the UK. By rescaling these values, we obtain our baseline calibration for hours, h, supply per worker which equals 0.424, per quarter. We therefore allow the measure of disutility of work, A, to freely adjust in order to target the value of h in our baseline calibration. The measure of production elasticity of working hours α_f in the conversion technology used in the hiring sector is set to 0.995, close to the value chosen by Christoffel and Kuester (2008).

As is common in the literature, we define unemployment benefit replacement ratio as $\rho_b = b/wh$, which allows us to express the measure of unemployment benefit, b, in terms of the model's steady state per capita wage income, wh. In our baseline solution ρ_b is calibrate to 0.38

in line Faccini, Millard, and Zanetti (2011). Empirical evidence suggests that collective bargaining plays a key role in determining the structure of wage in an economy – see Nickell and Layard (1999) and Cardoso and Portugal (2005), among others. In particular, Cardoso and Portugal find that high collective bargaining is associated with high bargained wage, in an empirical study which focuses on Portugal. In Portugal, collective bargaining takes place mainly at the sectorial level and has a total (workforce) coverage level of 62 percent – Venn (2009). In the UK collective bargaining is much more decentralised (operates at the company level) with a coverage level of 35 percent. As pointed out by Dabusinskas et al. (2016), converting these percentages into bargaining power as used in this model is not so straightforward. Thus, we assume that the measure of a worker's bargaining power, Φ, is symmetric, i.e., $\Phi = 0.5$ in line with Pissarides (2000) and Zanetti (2011). To satisfy the efficiency condition as outlined in Hosios (1990), we set the matching elasticity, μ, to equal $(1 - \Phi)$.

The calibration of firing cost often poses a challenge, since the estimates of its magnitude are seldom available. In order to circumvent this challenge, we follow Thomas and Zanetti (2009) and define the steady state firing cost ratio as $\rho_f = f/wh$. In the baseline calibration we set ρ_f to 0.063 per quarter based on the estimates provided by Bentolila and Bertola (1990) for the UK. We further assume that subsidies are not active in the steady state under our initial calibration, we therefore let $\zeta^V = \zeta^T = 0$.

As indicated by the Standard & Poor's credit rating of 2015, the UK is classified as reliable and stable with a triple 'A' rating, which reflects, to some extent, the relative ease with which it can borrow and lend to the rest of the world. We use this credit rating as basis (or proxy) to calibrate the parameter, κ, which measures the degree of capital mobility in our model. In particular, we set the initial value of κ to approximately 0.00088 to reflect a high degree of capital mobility. The choice of this value also enables us to target the share of aggregate investment in GDP of approximately 17 percent as given by the data average from 2000: Q1 to 2014: Q3 (ONS Statistics). To conclude our calibration exercise, we set the initial values of the measures of available varieties M and M^* to 1 and 10 and allow the price of imported varieties, p^*, to be determined from the steady state solution. The total factor productivity, φ, is set to ensure that the GDP equals unity in the baseline result.

The steady -state solution from the above calibration yield, approximately, the following shares: $M\pi/GDP$ = 0.2, I/GDP = 0.17, K/GDP = 6.8 and Nwh/GDP = 0.57, which are consistent with the UK data average over the last two decades, based on the ONS Statistics. Note that the share of private consumption turns out to be high, i.e., C/GDP = 0.808, since we do not consider government consumption expenditure. On average, C/GDP in the UK equals 0.61 between 2000: Q1 and 2014: Q3 based on ONS Statistics, while the share of government final consumption expenditure to the aggregate output for the same period is roughly 20 percent.

4.5 Steady State Properties and Economic Openness

The second column of Table 4.2 summarises the numerical solutions of the baseline calibration. In what follows we simulate the steady state version of the model which we have calibrated as described above in order to understand the long-run effects of: (i) a change in degree of economic openness and (ii) interacting measures of economic openness and labour market policies. The resulting comparative statics will shed light on the robustness and sensitivity of the benchmark steady state equilibrium as well as provide some policy insight regarding the role of these measures on the labour market.

4.5.1 Long-run Effects of Economic Openness

In investigating how changes in the degrees of openness affect the labour market, in particular unemployment, we consider two main measures of economic openness commonly referred to in the literature, namely: (i) the degree of capital mobility captured by κ, where a high (low) value of κ represents a low (high) openness to capital flow (Rodrik, 1998), and (ii) trade cost measured by τ, where also a high (low) value of τ captures low (high) trade openness (Ghironi & Melitz, 2005; Molana & Montagna, 2015). For clarity, we classify our exercise into scenarios, where: (i) κ and τ are both high, which we call the *pre-liberalisation* period (the baseline solution); (ii) κ is lowered, but τ remains at its calibrated value (partial-liberalisation in capital or partial-capital-liberalisation); (iii) κ remains at its original value, but τ is reduced (partial-liberalisation in trade or partial-trade-liberalisation); and finally, (iv) where both κ and τ are reduced (absolute-liberalisation).

Partial-liberalisation in capital: A decrease in the coefficient of capital mobility, κ, raises domestic capital, consumption, final output, and GDP. Vacancy creation rises, while unemployment falls.[18] The intuition for these results is that, everything else equal, a lower κ serves as incentive for investment opportunities, since it implies lower transaction cost of capital movement. This induces the household to raise domestic investment, I, which in turn increases aggregate capital K. For a given level of aggregate domestic demand for capital, Mk, the rise in K puts downward pressure on domestic return rate on capital, so r falls.[19] Also as K rises, the demand for Y and z rise too, leading to a higher marginal product of labour, and consequently, a higher vacancy creation and lower unemployment. The real marginal cost production, p_a, rises due to higher $\widetilde{w}$, but – given the ensuing decrease in r required to maintain the capital mobility condition (4), as K rises – the increase in p_a is moderated by lower r. The observed rise in p_a, however, raises p^d and reduces exported varieties, y^x, thus resulting in trade deficit (which is further worsened by the fact the y^* also rises) and capital outflow. The interest receipt on net

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[18] Table 4.2 reports the numerical results of the simulation exercises which considers different values of measures of economic openness.

[19] Note that in the initial steady state, we assume that there is no capital flow, which implies that the domestic demand for capital equals its supply $K = Mk$. Using the steady state version of the Euler equation (6) we obtain $I = \frac{\delta}{\kappa}\left[(1 + r^*) - \delta - \frac{1}{\beta}\right]$. Thus, keeping all else equal, a decrease in κ leads to higher I.

capital outflow leads to an improvement in the household disposable income, resulting in a higher consumption and capital accumulation.

This result is quite instructive and offers new insights theoretically. Contrary to conventional view (e.g., as suggested by Azariadis & Pissarides, 2007), the outflow of domestic capital may not necessarily result in higher unemployment. Our result shows that if capital is accumulated using domestic resources before being exported abroad in search of higher returns, capital outflow can be beneficial. There are two main driving forces here: we refer to the first as the *domestic demand effect* and the second, a *wealth effect*, through household disposable income. In the first, provided the rise in y^d resulting from the increase in investments is sufficiently large to not only offset the decrease in y^x, but also raise the aggregate intermediate productivity z, capital outflow will result in lower unemployment. Second, for the household, the outflow of capital means an increase in their financial wealth due to foreign return on capital flow. All else equal, the increase in income will further encourage investment and consumption, leading to more demand for labour service.

Partial-liberalisation in trade: Lower trade cost, in contrast, increases z by reducing the effective price of intermediate varieties, which makes the demand for export y^x higher. The increase in z translates into higher marginal product of labour and capital, and consequently, the real marginal cost, p_a. The price of intermediate varieties p^d rises by more in this case compared to the partial-capital-liberalisation, where lower r moderates its increase. This induces *expenditure switching effect* in the final goods sector, causing imported varieties, y^* to rise, while the demand for domestic product y^d drops. However, as suggested by our results, the decline in y^d is more than compensated by the increase in y^x, so labour demand rises, thus prompting more hiring activities, which then reduces unemployment.

Absolute-liberalisation: Compared to the individual cases above, our results show that a joint increase in the degree of trade openness and capital mobility delivers higher GDP and vacancy creation, leading to a much lower unemployment. Intuitively, while trade liberalisation tends to crowd out domestic demand as a result of cheaper imported varieties, the incentive to invest as a result of lower barriers to capital mobility raises domestic demand. Also, there is a significant increase in exported varieties when an increase in openness to capital mobility is accompanied by trade liberalisation. This joint effect provides a further boost to labour productivity that leads to greater employment.

4.5.2 Long-run Effects of Labour Market Reforms and Economic Openness

To this point, we have focused on the long-run effects of capital mobility and trade liberalisation on unemployment. However, as economies continue to witness increasing economic integration, most governments, undertake various labour market reforms at the same time. This is often justified on the grounds that such reforms enhance firms' ability to adjust to the forces of openness and to minimise job losses.[20] An growing number of literature has emphasized the role of labour market reforms on the effects of openness (Cosar et al., 2016; Kim, 2011; Helpman & Itskhoki, 2010; Head & Smits, 2004). As revealed in the introduction, the exact effects of labour market rigidity on unemployment in the presence of increased openness remain inconclusive. Here, we examine how the interaction of labour market reforms and openness measures (which we refer to as joint reform) affects unemployment, in line with Cosar et al. Before doing so, however, it is useful to first highlight the baseline effects of labour market reforms.

As reported in Table 4.3, for a constant rate of job destruction, η, unemployment falls following reforms which reduce benefits replacement and firing cost ratios, ρ_b and ρ_f, job creation and the per capita training costs, x^V and x^T, or introduce vacancy creation and training subsidies, ζ^V and ζ^T. A decrease in ρ_b primarily reduces the relative value of the unemployment of workers, which translates into lower real wage rate w – see equation (35). The fall in the real wage raises the marginal gain from hiring, J, inducing firms to create more vacancies which, by increasing market tightness and thus, the job finding rate of workers, leads to lower unemployment. Given the inter-sectoral linkage which characterises our model's economy, the effects of a reduction in ρ_b goes beyond the hiring sector. As ρ_b reduces, the eventual decrease in the real wage causes the price of effective labour service $\widetilde{w}$ to fall as well. The decrease in $\widetilde{w}$ will then induce further demand for labour services which means further reduction in unemployment.

Lower training cost and firing ratio, x^T and ρ_f, also raise the gain associated with a filled vacancy, J, making vacancy creation more attractive, and so V rises. As V increases, the job finding rate rises too, which then leads to lower unemployment. A lower x^V directly lowers the cost of creating vacancies relative to the gains associated with the vacancies when filled, as can be observed from condition (32). To restore the equilibrium condition (32), in which both the cost of and the gain from posting vacancies are equal, V must increase to lower the duration of vacancies, $(q^f)^{-1}$. This requires that market tightness rises, which then causes aggregate unemployment to fall. In addition to labour market reforms, the government can use ALMPs by subsidising either the training or vacancy creation costs of hiring firms. As suggested by the simulation results – reported in columns 7 and 8 of Table 4.3 – both subsidies enhance the performance of the labour market by raising market tightness, which then results in lower unemployment.

We now turn to the results of joint reform effects on unemployment. We consider 20 percent simultaneous reductions in the measures of openness and labour market reform instruments, with the exception of ALMPs where we assume 0.1 percentage point subsidy grants. Table 4.4 in Appendix 4 summarises the results of this simulation exercise. Interestingly, in all

[20] Cosar et al. (2016) document evidence of this in the Latin American Countries. Another evidence of this can be seen in the recent labour market reforms in favour a more flexible labour market in the face of increasing economic integration (European Commission, 2010).

instances where liberalisation in capital mobility or trade is accompanied by labour market reform, unemployment falls by much more compared to individual reforms/liberalisation. For instance, unemployment falls by 0.38 (from 10.46 to 10.08 percent) and 1.09 (from 10.46 to 9.37 percent) percentage points after a reduction in the measure of capital mobility and benefit, respectively, whereas it falls by approximately 1.43 percentage point following a joint capital-benefit reform. These results suggest that an economy can benefit from long-run capital liberalisation in terms of lower unemployment if accompanied by labour market reforms.

To appreciate this result, recall that capital liberalisation leads to a significant decrease in export y^x due to higher p^d, caused by increased marginal cost, p_a. This implies that the decrease in unemployment witnessed after capital liberalisation is driven only by the increase in domestic demand y^d. However, by attenuating the increase in w and, consequently, p_a, benefits reform helps moderate price p^d increase when a joint capital-benefit reform is undertaken compared to capital liberalisation in isolation. This consequently leads to a smaller decrease in y^x and, at the same time, further increase in y^d in the case of joint reform compared to individual capital liberalisation. A similar argument holds for joint trade-benefit reform: unemployment drops by 1.55 percentage points (from 10.46 to 8.91 percent), whereas trade liberalisation, in isolation, reduces unemployment by 0.51 percentage point (from 10.46 to 9.95 percent).

A reduction in firing cost together with capital (trade) liberalisation has a similar effect on unemployment as in joint capital-benefit (trade-benefit) reforms. However, unlike benefit reform alone, the impact of firing cost reform in isolation is quantitatively small. This is because, while benefit reform reduces the real wage by reducing workers' outside options, firing cost reform increases it. The reason is that, a lower firing cost raises the gain from hiring, J. As wages are negotiated, workers share from high J, resulting in higher real wage, which somewhat offsets the benefit from hiring more workers. Training subsidy has a similar mechanism as firing cost and the impact is also small quantitatively. Recruitment subsidy enhances the unemployment-reducing effect of capital (trade) liberalisation, and the mechanism operates in a similar way as benefit reform.

4.6 Dynamic Responses to Shocks

In this section, we explore the dynamic properties of the model by examining the impulse responses of variables to shocks. It is useful to start by examining the baseline results to highlight the behaviour of the economy to different shocks. We focus on shocks to productivity (TFP), foreign demand (FD) and the measures of openness. This is followed by assessing the how the degree of openness to international trade and capital mobility (discussed in the preceding section) drive the response of unemployment to TFP and FD shocks. We conclude this section by looking at how a more comprehensive form of labour market reforms and ALMPs shape the outcomes of short run trade and capital liberalisation. Note that the dynamic solution for the model is obtained by log-linearising the equation system describing the model economy around the stationary steady state using first order Taylor series approximation. The log-linearised equation system, thus, contains variables which are expressed as percentage deviations from respective steady state values.[21] Section 4B in Appendix 4 contains a summary of the equation system.

4.6.1 Baseline Results

Figures 4.1 and 4.2 display the impulse response function (IRFs) of selected variables to TFP and FD shocks, respectively. Qualitatively, the shapes of the IRFs following positive TFP and FD shocks are the same for most variables, especially those characterizing the labour market. In both instances, the productivity of labour and capital rise, intensifying their use as inputs for production. The cost of creating vacancies relative to labour productivity decreases, thereby inducing the hiring sector to step up recruitment activities and leading to a higher market tightness and job finding rate, and lower unemployment. Consistently, both shocks lead to increased household consumption and investment due to increase in household disposable income (HDI), driven mainly by labour income and profit distributed from the intermediate sector.

Quantitatively, however, the magnitude of impacts differs for both shocks: unemployment drops by approximately 0.5 and 0.013 at its lowest level below the steady state in response to TFP and FD shocks, respectively. This difference in magnitude of impact lies in the mechanisms through which the shocks affect the economy. Whilst a positive shock to FD raises the demand for intermediate varieties, z, by increasing exported varieties, y^x, the shock to TFP produces a rise in the quantity of intermediate varieties, z, by enhancing the productivity per unit of factor input (labour and capital), thus generating a stronger response in z on impact. Moreover, a rise in FD results in higher terms of trade (ToT) – defined as the relative price of export and import (p^d/p^*) – as the real marginal cost of production increases, thus inducing the final good producing sector to shift demand for intermediate input towards imported varieties y^* – consistent with Faia (2011). Hence, in the case of a positive FD shock, while z rises as a result of increased y^x, this increase is abated by the reduction in y^d. In contrast to FD, TFP shock lowers intermediate prices, hence the ToT, which further encourages the demand for intermediate varieties both in the domestic economy and abroad, leading to greater gains from hiring and lower unemployment.

Figures 4.3 and 4.4 respectively plot the dynamics (IRFs) of the same set of variables following shocks which reduce barriers to international capital mobility (κ) and trade (τ). Clearly, both shocks result in lower unemployment as expected, which explains why there is

[21] The analyses of the short run dynamics of the model are carried out using Dynare version 4.4.3 for Matlab, Adjemian et al. (2014). Dynare is a *toolbox* for Matlab that is increasingly used for solving economic models – for instance see, Cahuc and Barbanchon (2010), Gorodnichenko and Weber (2016), Mandelman and Zanetti (2008), Sophocles, Plagborg-Møller, and Stock (2014), and Weber (2015). More information about Dynare are available at http://www.dynare.org/. Another software that can be used to solve DSGE model is the Perturbation AIM, developed by Swanson, Anderson, and Levin (2006), which is implementable in Mathematica; see, http://www.ericswanson.us/perturbation.html for more information.

long-run lower unemployment in the aftermath of liberalisation, with a lower τ producing greater impact on unemployment than lower κ. As shown in Figure 4.4, a reduction in τ raises the demand for exported varieties, y^x, due to lower effective price of export at the point of delivery. However, given that the effective price of imports also reduces, lower trade cost induces expenditure switching effect, shifting demand towards imported varieties y^* and causing y^d to fall. However, the increase in exports – which more than compensates for the drop in y^d – causes z to rise, thus resulting in higher labour productivity, which then generates higher vacancy creation and lower unemployment. In the case of reduction in barriers to capital mobility (Figure 4.3), labour productivity also rises, but unlike the effect of trade cost, the rise in labour productivity is driven by the increase in domestic demand for intermediate goods, y^d. Exported varieties increase initially, but drop as the price of intermediate goods rises, which is expected based on the result from the previous section. Despite the decrease exported varieties, the rise in domestic demand induces increase in vacancy creation, leading to lower unemployment.

4.6.2 Economic Openness and Shock Propagation

How does the degree of economic openness shape the dynamic response of unemployment to aggregate shocks? As already highlighted in the introduction, the prediction of a model with a higher capital mobility is that, in response to a positive productivity shock, unemployment responds faster with greater amplitude relative to an economy with lower capital mobility (Azariadis & Pissarides, 2007). This result is supported by Vallanti (2015), who empirically examined the role of capital mobility on unemployment response to TFP shock, using a panel of OECD countries over a 30-year period. Note that both Azariadis and Pissarides (2007) and Vallanti (2015) consider extreme cases of economic openness, where an economy is either open or closed to international capital mobility. Instead, a key feature of this paper is that we allow for varying degrees of openness to international capital mobility in addition to international trade openness, then explore how they shape the response of the economy to shocks. (This is because most economies – including the UK in which our calibration is based on – are open to the rest of the world and what matters is the extent to which control is exerted on capital and trade flows in and out of the economy.) We therefore consider our exercise under the steady state scenarios outlined in Section 4.5, where the long-run measures of openness, κ and τ, are varied. Here, we focus on TFP and FD shocks. While the former allows us to compare our results to the above studies, the latter enables us to examine how global economic developments affect the domestic economy as adduced by Chowla et al. (2014).

Figure 4.5 displays the impulse response of unemployment to positive one percent TFP and FD shocks. As suggested by the impulse response functions, the qualitative effect of TFP shock on unemployment remains unchanged, but the responses are enhanced as a consequence of increased openness: adjustment of unemployment to TFP shock becomes faster and the trough effects (i.e., the reduction in unemployment) are larger in all scenarios. The response of unemployment under scenario (ii) confirms the prediction of Azariadis and Pissarides (2007). As we will further explain below, the key to this result hinges on the extent to which agents have access to international lending and borrowing facilities – i.e., the degree of capital mobility which has been largely ignored in the literature. In the presence of increased access to international capital facility, agents are able to borrow and lend as necessary to smooth out the effects of shocks on the economy, which then enhances the effects of TFP shock on unemployment. In scenario (i), the pre-liberalisation period, unemployment falls by less due to higher barriers to capital mobility, together with high trade cost in the steady state. In scenarios (ii) and (iii), with partial liberalisation in capital and trade, the positive effects of TFP shock on unemployment becomes larger (and much larger under scenario (iv)) relative to scenario (i).

As is clear from Figure 4.5, in the partial capital liberalisation period with a decreased κ (scenario (ii)) the response of K to TFP shock is muted – intuitively, K becomes less sensitive and able to absorb more shocks. This is because lower transaction cost of capital, implied by the reduction κ, means that private agents can quickly access international facilities to deal with domestic capital requirements in response to TFP shock. To see how this affects the response of unemployment, recall that a positive TFP shock intensifies the demand for capital. With less barriers to capital mobility, there is inflow of foreign capital, which results in current account deficit $r^{*}(Mk - K) > 0$ and produces negative *wealth effect,* since interest payment must be made on net capital flow. The household disposable income therefore drops, dampening the response of consumption to TFP shock. From the hiring sector, the weakening in the response of consumption level lessens the continuation value of vacancy (see the vacancy creation condition (32)). However, given that a positive trade balance is required to offset this deficit (thus, to ensure that a zero balance of payment (BoP) is maintained), export rises more strongly while the response of import weakens. The former therefore boosts labour productivity, which abates the negative effect induced by the reduction in the continuation value of a job. This in turn leads to further vacancy creation and employment, prompting further decline in unemployment below its pre-liberalisation level.

In the benchmark economy and partial trade liberalisation period (scenario (iii)), with low trade cost (τ) and high barriers to capital mobility (κ), K becomes very sensitive and unable to absorb shock. The impact of a positive TFP shock is therefore partly transmitted to the rest of the economy through rapid adjustment in domestic investment and capital accumulation required to meet the capital needs of domestic firms. The intuition is that, by reducing access to international capital facilities, a higher barrier to capital mobility (high κ) forces private agents to articulate an *investment plan*. Under this condition, the way K responds depends on whether or not trade is liberalised. As in scenario (iii), with lower trade cost, K rises significantly – intuitively, in anticipation of higher capital demand resulting from increase in export induced by partial trade liberalisation. This can be seen by comparing the impulse response of y^{x} under the two scenarios (i and iii) with high κ. As can be seen in Figure 4.6, though the response of y^{x} is initially stronger in scenario (i), this is not sustained as the impact of shock dies out, whereas in scenario (iii), the response becomes more resilient. In general, unemployment drops more significantly in scenario (iii) than in (i), even with high κ , due to increased y^d required to increase investment, and export whose response becomes stronger than the benchmark impulse.

Under absolute liberalisation, scenario (iv), both with lower τ and κ, there is stronger response in exported variety, y^x – compared to scenario (iii) – due to inflow of capital. But compared to scenario (ii), capital inflow is much less under scenario (iv), pointing to the fact that private agents are able to invest to some extent to meet the domestic needs of capital. Consequently, there is strong in domestic demand for intermediate goods, y^d, which together with y^x, explains why scenario (iv) produces the greatest drop in unemployment in response to TFP shock of equal size.

As with TFP shock, the degree of openness to capital mobility and international trade also play crucial roles in shaping the response of unemployment to FD shock, as shown by the second panel of Figure 4.5. Surprisingly, however, while a higher degree of openness to capital mobility amplifies the response of unemployment to TFP shock, it dampens its response to FD shock. By contrast, the magnitude of adjustments in unemployment following both shocks are much larger in the two scenarios associated with lower trade cost (scenarios iii and iv). These differences are attributable to the way both shocks affect the economy, in particular the response of ToT. As already noted from the baseline results discussed above, a positive FD shock raises y^x on impact and translates into lower unemployment due to higher demand for labour. However, the ensuing ToT appreciation causes y^* to rise and y^d to fall, thus reducing the aggregate impact of FD on z and, consequently, on unemployment. In scenario (ii) with a low κ, the response of y^x is much stronger as private agents are able to import foreign capital required to support domestic production. There is, however, a dampening effect on consumption as a result of interest payment on capital inflow which, together with a decrease in y^d, weakens the response of unemployment. In scenario (iii), with limited access to foreign capital, as before, the household investment savings drive rises, thereby leading to a surge in capital accumulation in response to FD shock. Domestic return rate initially rises to attract capital inflow, as illustrated in Figure 4.7. However, as capital rises, the ensuing decline in the return rate induces capital outflow. Since this implies that agents must receive interest on net capital flow, there is positive wealth effect which translates into increase in consumption and in the continuation value of vacancies. Consequently, vacancy creation rises significantly, thus generating stronger response in unemployment than in scenario (ii). Under absolute liberalisation in trade and capital (scenario (iv)), the extent to which agents build up domestic capital in response to FD shock reduces as lower barriers to capital mobility induces inflow of foreign capital. The negative wealth effect generated by payment of net capital inflow therefore dampens consumption and, consequently, unemployment.

4.6.3 Labour Market Reform (Structure) and Unemployment Dynamics

In Section 4.5, we evaluated the implications of individual labour market reforms and ALMPs, then showed how their interaction with openness determined the response of unemployment. However, the recent drive towards a more comprehensive (flexible) labour market reform (the so-called *flexicurity* system) among the EU member states is justified by the threats posed by globalisation (Eurofound, 2007; European Commission, 2010). In this subsection, we try to mimic the features of the flexicurity welfare system, then compare the results thereof with the other types of welfare systems presently operated elsewhere within the EU.

The concept of flexicurity rests on two principles: flexibility and social security (Andersen, 2012). While flexibility relates to hiring and firing regulations which enhance domestic firms' ability to adjust to shocks, thus reducing consequent impact on unemployment, social security aims at providing protection for workers who are unemployed through the provision of, e.g., unemployment benefits insurance. In the context of our model, the flexicurity system can be captured by a low cost of vacancy creation, low firing cost ratio, and high unemployment benefit replacement rate.[22] Recent theoretical studies within this line of research have attempted to investigate the effects of labour market structure on unemployment in response to increased economic openness. However, most of these typically focus on static analysis and do not consider interactions of policy instruments (Du et al., 2015; Head & Smits, 2004; Helpman & Itskhoki, 2010; Kim, 2011). However, as pointed out by Blanchard and Giavazzi (2003), the real-world labour markets reflect a tight link in the use of different policies measure. The benefits of policy combination has also been stressed by Blanchard and Tirole (2008) in their paper, which studies the joint effects of employment protection legislations and unemployment benefits.

Generally, in the EU, besides the flexicurity system, there currently exists other forms of welfare systems such as the *liberal* and the *Mediterranean* welfare systems. Spain is a notable example of the Mediterranean welfare system, one characterised by high unemployment benefit, job creation and firing cost structures, while the UK features a liberal system. The liberal system typically features low unemployment benefit and firing cost, and a moderate cost of vacancy creation. Given the current effort to achieve a more flexible labour market within the EU, a natural question is – how does the flexicurity compare with other existing welfare systems? To answer this question, we recalibrate benefit replacement ratio, ρ_b, firing cost ratio, ρ_b, (which we refer to employment protection legislation – EPL – in the literature) and vacancy creation cost, x^V, given that they reflect the distinctive labour market features of the various welfare systems. We retain the baseline calibration as the liberal (UK) system and use Denmark (DK) and Spain (ES) to capture the flexicurity and Mediterranean systems respectively, keeping all other exogenous parameters constant at their baseline values.

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[22] As recently stressed by Montagna et al. (2016), the concept of flexicurity is complex and its implementation takes different forms. The authors however show that it is possible to have a combination of reforms which enhances firms' flexibility and at the same time provide benefit support to the unemployed.

Based on the evidence provided in Nickell et al. (2005), we set benefit replacement ratio ρ_b for ES and DK to 0.58 and 0.53, respectively. In order to obtain a consistent calibration for ρ_f, we apply a similar method as Brown et al. (2015): letting ρ_f^j and EPL^j represent the magnitude of the estimate of ρ_f and the employment protection index for j = ES, DK, set $\rho_f^j = \rho_f^{UK}\left(\frac{EPL^j}{EPL^{UK}}\right)$. Nickell et al. (2005) provide evidence of EPL indices for ES and DK, using which we obtain the value of ρ_f = 0.43 and 0.22 respectively. Finally, we use vacancy creation cost x^V to target the average long-run unemployment rate of 6 percent and 17 percent for DK and ES. This requires setting x^V to 0.13 and 0.43, respectively. In what follows, we consider the impact of 1 percent standard deviation increase in capital and trade liberalisation as well as TFP and FD shocks.

Figure 4.8 markedly reveals key differences in the adjustment of unemployment to shocks under different welfare systems. In more flexible liberal and flexicurity welfare systems, the impulse of unemployment is more enhanced compared to the more rigid Mediterranean system. Since the shape of the impulse of unemployment is approximately the same for TFP, FD and trade liberalisation shocks, we use trade liberalisation as a basis for our analysis. Quantitatively, for trade liberalisation, unemployment drops more significantly by approximately 0.08 and 0.07 percentage points in the liberal and flexicurity systems, respectively, compared to the 0.052 percentage points reduction in the Mediterranean system. These results are driven by the effects of our welfare state configuration on the value of a job match, which in turn determine the average cost of creating vacancies (see equation (32)). Given the inter-sectoral linkage in our economy, the feedback effect from the labour market determines the extent to which labour service is demanded by the intermediate sector. In the flexicurity and liberal systems, with a relatively low cost of vacancy creation, a positive trade shock leads to higher labour demand, which in turn enhances the response of unemployment.

In the Mediterranean welfare system, the rigidity in the labour market structure limits the benefit of trade liberalisation: the response of unemployment is much slower and protracted than in the other welfare systems. This gradual adjustment is explained by the existence of high vacancies creation cost, combined with high expected cost of firing. In fact, depending on the magnitude of impact of a shock on the value of job, unemployment could rise temporarily as the result of more rigid labour market, as with capital liberalisation shock. As already noted, capital liberalisation raises productivity by increasing domestic demand. With a flexible labour market, domestic intermediate price initially drops, thus encouraging export. With a more rigid labour market, the cost of labour to the hiring firm is higher. The feedback effect from the labour market therefore translates into higher marginal cost of production, leading to higher domestic intermediate prices. Thus, unlike the flexible labour market, this increase in price reduces export, while import demand rises against domestic demand. This composite effect, hence, causes a temporal rise in unemployment on impact, before falling below, then adjusting back to its long-run steady state.

4.6.4 Active Labour Market Policies and Unemployment Dynamics

Another important aspect of the labour market policies which has drawn the attention of researchers is the use of ALMPs – these include programmes aimed at enhancing the qualification and boosting the prospects of the unemployed (Andersen & Svarer, 2007). Here we first investigate the responses of selected variables to vacancy and training subsidies, then assess how permanent changes in these subsidies drive the response of unemployment to shocks to international trade and capital mobility. Note that, in our model, ALMPs are captured by training and vacancy creation subsidies.

Figure 4.9 plots the adjustment dynamics (IRFs) of selected quantities following positive vacancy and training subsidy shocks. The right- and left-hand side of y-axis respectively represent percentage deviation from the steady state of each variable in response to training and vacancy creation subsidies, while the x-axis represents quarters after shock. Qualitatively, both subsidies have similar impact on quantities, but these impacts differ in terms of the magnitude: the shock to vacancy creation subsidy results in stronger response with respect to the peak effects compared to training subsidy. Generally, a rise in either vacancy or training subsidies clearly generates a significant increase in employment through a higher vacancy creation, accompanied by a rise in the market tightness, on impact. Higher market tightness in turn increases in the job finding rate, and so unemployment drops below its steady state, reaching its lowest level around 6^{th} and 5^{th} quarters after vacancy creation and training shocks respectively. With more people in employment, aggregate output and consumption level go up too, with the former reaching its highest level around the same time that employment peaks. Since both subsidies reduce the marginal cost of production, by lowering the price of labour service to the intermediate sector, intermediate price level drops, which then triggers increase in the domestic and foreign demand for intermediate varieties.

As suggested by the impulse response of labour market variables, vacancy creation subsidies appear to be more effective in lowering unemployment and in fostering increase in GDP compared to training subsidies. On one hand, and on impact, a positive one percent standard deviation vacancy creation subsidy shock raises the number of vacancies by approximately 0.2 percent, at the peak, while unemployment falls by almost 0.07 percentage points below its steady state level. On the other hand, a positive shock to training subsidy of equal magnitude, raises vacancy creation marginally by 0.004 percent, while unemployment drops to its lowest level of approximately 0.003 percent. A plausible explanation for the difference in the magnitude of impact is that training subsidy is not necessarily a major constraint to the hiring firms since the calibrated benchmark cost incurred for training each worker is generally small compared to the cost of recruiting workers. In the steady state, the implied cost of recruiting each worker or creating each vacancy and training each worker are respectively 0.32 and 0.007, which are approximately 1.6 and 0.7 percent of the economy’s GDP. Figure 4.10 in Appendix 4 shows the impulse response of unemployment to capital and trade liberalisation in the presence of long-run ALMPs. As suggested by the impulses, the effects of training subsidy on the dynamic adjustment of unemployment is muted, whereas vacancy subsidy enhances the speed of adjustment both in terms of the impact effects and adjustment back to the steady state.

4.7 Conclusion

Empirical and theoretical evidence suggest that links between nations – globalisation – can serve as important channels through which economic crisis can be propagated. Consequently, many countries, especially within the EU, have resorted to labour market reforms as a means to increase the market's flexibility in adjusting to aggregate shocks. This chapter developed a small open economy DSGE model with search and matching frictions in the labour market to study the effects of economic openness on unemployment dynamics. A novel feature of this chapter is that it explicitly considers an economy that is linked to the rest of the world through international trade and capital movement, which has in the past been studied separately in the literature, with the interaction of both providing a deeper understanding of the dynamics of unemployment.

We found that a reduction in barriers to international capital mobility, by opening up investment opportunities, can result in higher labour productivity, output and lower unemployment. A lower impediment to international trade is also found to have a similar unemployment-reducing effect via an increase in foreign demand for domestic goods; but when jointly implemented with a higher capital mobility, the effect on unemployment is larger. Our model predicts that the impact of shocks on the dynamics of unemployment differs depending on the initial degree of exposure to international trade and capital mobility. Specifically, we found that a higher degree of openness to international capital mobility can result in unemployment volatility in response to domestic productivity shock. While this result is by no means novel (e.g. as demonstrated by Azariadis and Pissarides, 2007), we show, however, that when accompanied by an increase in openness to trade, a higher degree of capital mobility can result in a much larger unemployment fluctuation in response to the same shock. Strikingly, our model indicates that shocks with different origins are likely to have contrasting effect on the adjustment of unemployment, depending on the degree of barrier to international capital mobility.

Finally, our model indicates that taken as a package, trade openness and labour market reforms, or capital mobility and labour market reforms can deliver more benefit to an economy in terms of improved employment rate than individual reforms. Furthermore, given the emphasis on labour market flexibility, we calibrate the model to replicate the labour market features of three welfare systems (the flexicurity, liberal and the Mediterranean welfare systems) in the EU and investigate the response of unemployment under each system. Our results show that the flexicurity and liberal welfare systems with more flexibility in hiring and firing regulations produce larger volatility in unemployment in response to shocks. The Mediterranean system with more rigid employment rules, on the other hand, dampens the peak effects of unemployment, with slower reversion to the steady state.

The model we developed in this chapter did not consider skill heterogeneity – such as the low- and high-skilled workers. However, there is increasing concern that globalisation may have different effects on workers with different skill types in terms of income inequality and work displacement (Brecher & Chen, 2010; Feenstra & Hanson, 2001; Helpman, Itskhoki, & Redding, 2010). The introduction of skill heterogeneity into the model – which we leave for future research – to study how the interaction of openness in capital and trade can affect workers with different skills will be an interesting departure from this work.

Appendix 4

4A Mathematical Derivations

4A.1 Household's Optimisation Problem

The present discounted lifetime utility of the household is given by

$$E_t \sum_{s=0}^{\infty} \beta^s \left[\frac{\xi_{ct+s} C_{t+s}^{1-\alpha_c}}{1-\alpha_c} - A \int_0^1 \frac{n_{jt+s} h_{jt+s}^{1+\alpha_h}}{1+\alpha_h} dj \right]. \qquad (A1)$$

The budget constraint, evolution of capital and the condition for capital mobility are as follows:

$$\begin{aligned} C_{t+s} + I_{t+s} + r_{t+s}^{*} \left(M_{t+s} k_{t+s} - K_{t+s} \right) = \\ \int_0^1 w_{jt+s} n_{jt+s} h_{jt+s} dj + \left(1 - N_{t+s}\right) b_{t+s} + \Pi_{t+s} + r_{t+s} M_{t+s} k_{t+s} - T_{t+s}, \end{aligned} \qquad (A2)$$

$$K_{t+s+1} = I_{t+s} + \left(1-\delta\right) K_{t+s}, \qquad (A3)$$

$$r_{t+s} = r_{t+s}^{*} + \kappa_{t+s} \left(M_{t+s} k_{t+s} - K_{t+s} \right). \qquad (A4)$$

The household maximises ($A1$) subject to the constraints ($A2$), ($A3$) and ($A4$). The Lagrangian of the household optimisation problem can be written as[23]

$$\mathcal{L}_H = E_t \sum_{s=0}^{\infty} \beta^s \left(\left\{ \frac{\xi_{ct+s} C_{t+s}^{1-\alpha_c}}{1-\alpha_c} - A \frac{N_{t+s} h_{t+s}^{1+\alpha_h}}{1+\alpha_h} \right\} + \Lambda_{t+s} \left\{ \begin{aligned} N_{t+s} w_{t+s} h_{t+s} + \left(1-N_{t+s}\right) b + \left(1 - \delta + r_{t+s}^{*} - \kappa_{t+s} M_{t+s} k_{t+s}\right) K_{t+s} \\ + \kappa_{t+s} \left(M_{t+s} k_{t+s} \right)^2 - K_{t+s+1} + \Pi_{t+s} - T_{t+s} - C_{t+s} \end{aligned} \right\} \right). \qquad (A5)$$

The first order conditions with respect to $\left\{ C_{t+s} \right\}$ and $\left\{ K_{t+s+1} \right\}$ are given by

$$\frac{\partial \mathcal{L}_H}{\partial C_{t+s}} : \quad E_t \left[\beta^s \xi_{ct+s} C_{t+s}^{-\alpha_c} - \Lambda_{t+s} \right] = 0 ; \; s \geq 0 , \qquad (A6)$$

$$\frac{\partial \mathcal{L}_H}{\partial K_{t+s+1}} : \quad E_t \left[\beta^{s+1} \Lambda_{t+s+1} \left(1 - \delta + r_{t+s+1}^{*} - \kappa_{t+s+1} M_{t+s+1} k_{t+s+1} \right) - \beta^s \Lambda_{t+s} \right] = 0 ; \; s \geq 0 . \qquad (A7)$$

Setting $s = 0$ in ($A6$) and ($A7$) and then rearranging, we obtain the following equations:

$$\Lambda_t = \xi_{ct} C_t^{-\alpha_c} , \qquad (A6')$$

$$\Lambda_t = \beta E_t \left[\Lambda_{t+1} \left(1 - \delta + r_{t+1}^{*} - \kappa_{t+1} M_{t+1} k_{t+1} \right) \right] , \qquad (A7')$$

which yield equations (5) and (6) in the text.

[23] We drop the firm index j since we consider a symmetric equilibrium where all firms make similar decision and workers supply the same number of hours to work.

4A.2 Final Good Sector's Optimisation Problem

The profit of the representative firm in the final good producing sector is given by

$$\Pi_{Yt} = P_t Y_t - \left(\int_{i \in M_t} p_{it}^d y_{it}^d di + \int_{i \in M_t^*} \tau_t p_{it}^* y_{it}^* di \right), \tag{A8}$$

which is maximised subject to production function,

$$Y_t = \left(M_t^{\frac{\lambda-1}{\sigma}} \int_{i \in M_t} \left(y_{it}^d \right)^{1-1/\sigma} di + M_t^{*\frac{\lambda-1}{\sigma}} \int_{i \in M_t^*} \left(y_{it}^* \right)^{1-1/\sigma} di \right)^{\frac{1}{1-1/\sigma}}. \tag{A9}$$

The Lagrangian formulation of the firm's maximisation problem can be expressed as

$$\begin{aligned} L_Y = {} & P_t Y_t - \left(\int_{i \in M_t} p_{it}^d y_{it}^d di + \int_{i \in M_t^*} \tau_t p_{it}^* y_{it}^* di \right) \\ & + \mathcal{F}_t \left\{ \left(M_t^{\frac{\lambda-1}{\sigma}} \int_{i \in M_t} \left(y_{it}^d \right)^{1-1/\sigma} di + M_t^{*\frac{\lambda-1}{\sigma}} \int_{i \in M_t^*} \left(y_{it}^* \right)^{1-1/\sigma} di \right)^{\frac{1}{1-1/\sigma}} - Y_t \right\}, \end{aligned} \tag{A10}$$

where $\mathcal{F}_t$ is the Lagrange multiplier associated with (A9). Differentiating (A10) w.r.t Y_t, y_{it}^d, y_{it}^* and $\mathcal{F}_t$ and setting the results equal to zero we have

$$\frac{\partial L_Y}{\partial Y_t} = P_t - \mathcal{F}_t = 0. \tag{A11}$$

$$\begin{aligned} \frac{\partial L_Y}{\partial y_{it}^d} = {} & -M_t p_{it}^d + \mathcal{F}_t \left(\frac{\sigma}{\sigma - 1} \right) \left(\left(M_t^{\frac{\lambda-1}{\sigma}} \int_{i \in M_t} \left(y_{it}^d \right)^{1-1/\sigma} di + M_t^{*\frac{\lambda-1}{\sigma}} \int_{i \in M_t^*} \left(y_{it}^* \right)^{1-1/\sigma} di \right)^{\frac{1}{\sigma-1}} \right) \times \\ & M_t^{\frac{\lambda-1}{\sigma}} \left(\frac{\sigma-1}{\sigma} \right) M_t \left(y_{it}^d \right)^{-1/\sigma} = 0. \end{aligned} \tag{A12}$$

$$\begin{aligned} \frac{\partial L_Y}{\partial y_{it}^*} = {} & -M_t^* \tau_t p_{it}^* + \mathcal{F}_t \left(\frac{\sigma}{\sigma - 1} \right) \times \\ & \left(\left(M_t^{\frac{\lambda-1}{\sigma}} \int_{i \in M_t} \left(y_{it}^d \right)^{1-1/\sigma} di + M_t^{*\frac{\lambda-1}{\sigma}} \int_{i \in M_t^*} \left(y_{it}^* \right)^{1-1/\sigma} di \right)^{\frac{1}{\sigma-1}} \right) M_t^{*\frac{\lambda-1}{\sigma}} \left(\frac{\sigma-1}{\sigma} \right) M_t^* \left(y_{it}^* \right)^{-1/\sigma} = 0. \end{aligned} \tag{A13}$$

$$\frac{\partial L_Y}{\partial \mathcal{F}} = \left(M_t^{\frac{\lambda-1}{\sigma}} \int_{i \in M_t} \left(y_{it}^d \right)^{1-1/\sigma} di + M_t^{*\frac{\lambda-1}{\sigma}} \int_{i \in M_t^*} \left(y_{it}^* \right)^{1-1/\sigma} di \right)^{\frac{1}{1-1/\sigma}} - Y_t = 0. \tag{A14}$$

Evaluating (A12) and (A13) using $\mathcal{F}_t = P_t$ and $Y_t^{\frac{\sigma-1}{\sigma}} = M_t^{\frac{\lambda-1}{\sigma}} \int_{i \in M_t} \left(y_{it}^d \right)^{1-1/\sigma} di$

$+M_t^{*\frac{\lambda-1}{\sigma}} \int\limits_{i \in M_t^*} \left(y_{it}^*\right)^{1-1/\sigma} di$ from equations (A11) and (A14) respectively, and rearranging we obtain the demand functions for domestic and imported intermediate varieties as,

$$y_{it}^d = M_t^{\lambda-1} Y_t \left(\frac{p_{it}^d}{P_t}\right)^{-\sigma}, i \in M_t, \tag{A15}$$

and

$$y_{it}^* = M_t^{*\lambda-1} Y_t \left(\frac{\tau_t p_{it}^*}{P_t}\right)^{-\sigma}, i \in M_t^*. \tag{A16}$$

The domestic price index can be obtained by substituting (A15) and (A16) into (A8) – noting that under the perfect competition assumption we require $\Pi_{Yt} = 0$. The resulting price index satisfies,

$$P_t = \left(M_t^{\lambda-1} \int\limits_{i \in M_t} \left(p_{it}^d\right)^{1-\sigma} di + M_t^{*\lambda-1} \int\limits_{i \in M_t^*} \left(\tau_t p_{it}^*\right)^{1-\sigma} di\right)^{\frac{1}{1-\sigma}}. \tag{A17}$$

4A.3 Hiring Sector's Optimisation Problem

Each firm $j \in (0,1)$ maximises the present discounted value of expected profit given by

$$maxE_t \sum_{s=0}^{\infty} \Omega_{t+s} \left[n_{jt+s} \tilde{w}_{t+s} h_{jt+s}^{\alpha_f} - n_{jt+s} w_{jt+s} h_{jt+s} - \left(1-\zeta_{t+s}^T\right) x^T n_{jt+s} - \left(1-\zeta_{t+s}^V\right) x^V v_{jt+s} - \eta n_{jt+s} f_{t+s}\right],$$

where $\Omega_{t+1} = \beta\left(\frac{\Lambda_{t+1}}{\Lambda_t}\right)$ is defined as the stochastic discount factor, subject to the firm's law of motion of employment,

$$n_{jt+s} = (1-\eta) n_{jt+s-1} + q_{t+s}^f v_{jt+s}. \tag{A18}$$

Let J_{jt} denote the Lagrange multiplier associated with (A18), the Lagrangian for each firm can be written as

$$\mathcal{L}_F = E_t \sum_{s=0}^{\infty} \Omega_{t+s} \Big\{ n_{jt+s}\left(\tilde{w}_{t+s}\tilde{h}_{jt+s} - w_{jt+s} h_{jt+s} - \left(1-\zeta_{t+s}^T\right) x^T - \eta f_{t+s}\right) - \left(1-\zeta_{t+s}^V\right) x^V v_{jt+s}$$
$$+ J_{jt+s}\left[(1-\eta) n_{jt+s-1} + q_{t+s}^f v_{jt+s} - n_{jt+s}\right] \Big\}.$$

(A19)

The FOCs w.r.t. $\{v_{jt+s}\}$ and $\{n_{jt+s}\}$ are summarised, for s = 0, as follows

$$\frac{\left(1-\zeta_t^V\right) x^V}{q(\theta_t)} = J_{jt} \tag{A20}$$

and

$$J_{jt} = \tilde{w}_t \tilde{h}_{jt} - w_{jt} h_{jt} - \left(1-\zeta_t^T\right) x^T - \eta f_t + (1-\eta) E_t \Omega_{t+1} J_{jt+1}, \tag{A21}$$

which respectively represent equations (30) and (31) in the text.

4A.4 Wage Determination

From the first order condition with respect to w_{jt} we have $\Phi J_{jt} = (1-\Phi) W_{jt}$, i.e., equation (34) . Substituting equations (31) and (33) into the FOC for w_{jt}, and rearranging, we obtaining

$$w_{jt}h_{jt} = \Phi\left[\tilde{w}_t\tilde{h}_{jt} + \left(1-\zeta_t^T\right)x^T - \eta f_t + (1-\eta)E_t\Omega_{t+1}\frac{\left(1-\zeta_{t+1}^V\right)x^V}{q_{t+1}^f}\right]$$
$$+(1-\Phi)\left[\left(b_t + \frac{Ah_{jt}^{1+\alpha_h}}{(1+\alpha_h)\Lambda_t}\right) - (1-\eta)E_t\Omega_{t+1}\left(1-q_{t+1}^w\right)W_{jt+1}\right].$$

Using $\Phi J_t = (1-\Phi)W_t \Rightarrow W_t = \frac{\Phi}{(1-\Phi)}J_t$; $W_t = \frac{(1-\Phi)}{\Phi}\frac{\left(1-\zeta_t^V\right)x^V}{q_t^f}$, the above becomes

$$w_{jt}h_{jt} = \Phi\left[\tilde{w}_t\tilde{h}_{jt} + \left(1-\zeta_t^T\right)x^T - \eta f_t + (1-\eta)E_t\Omega_{t+1}\frac{\left(1-\zeta_{t+1}^V\right)x^V}{q_{t+1}^f}\right]$$
$$+(1-\Phi)\left[\left(b_t + \frac{Ah_{jt}^{1+\alpha_h}}{(1+\alpha_h)\Lambda_t}\right) - (1-\eta)E_t\Omega_{t+1}\left(1-q_{t+1}^w\right)\frac{(1-\Phi)}{\Phi}\frac{\left(1-\zeta_{t+1}^V\right)x^V}{q_{t+1}^f}\right].$$

After rearranging the above we obtain the real wage equation

$$w_{jt}h_{jt} = \Phi\left[\tilde{w}_t\tilde{h}_{jt} - \left(1-\zeta_t^T\right)x^T - \eta f_t + (1-\eta)E_t\Omega_{t+1}\left(1-\zeta_{t+1}^V\right)x^V\theta_{t+1}\right]$$
$$+(1-\Phi)\left[b_t + \frac{Ah_{jt}^{1+\alpha_h}}{(1+\alpha_h)\Lambda_t}\right]. \qquad (A22)$$

4A.5 Optimal Hours of Work

The first order condition with respect to h_{jt} yields

$$\Phi\frac{\partial W_{jt}}{\partial h_{jt}}J_{jt} + (1-\Phi)\frac{\partial J_{jt}}{\partial h_{jt}}W_{jt} = 0, \qquad (A23)$$

where $\frac{\partial W_{jt}}{\partial h_{jt}} = w_{jt} - \frac{Ah_{jt}^{\alpha_h}}{\Lambda_t}$ and $\frac{\partial J_{jt}}{\partial h_{jt}} = \tilde{w}_t e_t h_{jt}^{(\alpha_f-1)} - w_{jt}$. Substituting these partial derivatives into ($A23$) and solving using equation (34) in the text yields the solution for optimal hours per worker as

$$\frac{Ah_{jt}^{\alpha_h}}{\Lambda_t} = \tilde{w}_t e_t h_{jt}^{\alpha_f-1}. \qquad (A24)$$

4B Summary of Equilibrium System

The summary of the equilibrium system is presented here according each equation (Eq), the steady state (SS) and log-linearised (LL) versions. In the absence of shocks, the economy converges to a steady state where all variables are constant; hence, $\psi_{\Upsilon}=0$. In the log-linearised version, variables with 'hat' denote log-deviation from their steady state, while variables without time subscript denote steady state value.

Household budget constrain:

Eq: $C_t + I_t = w_t N_t h_t + (1-N_t) b_t + M_t \pi_t + r_t M_t k_t - T_t - r_t^* (M_t k_t - K_t)$.

SS: $C + I = wNh + (1-N) b + M\pi + rMk - T - r^* (Mk - K)$.

LL: $C\hat{C}_t + I\hat{I}_t + T\hat{T}_t = wNh\left(\hat{w}_t + \hat{N}_t + \hat{h}_t\right) + (1-N) b\hat{b}_t - bN\hat{N}_t$

$+ M\pi\left(\hat{M}_t + \hat{\pi}_t\right) + rMk\left(\hat{r}_t + M_t + \hat{k}_t\right) - r^* Mk\left(\hat{M}_t + \hat{r}_t^* + \hat{k}_t\right) + r^* K\left(\hat{r}_t^* + \hat{K}_t\right)$.

Law of motion for capital:

Eq: $K_{t+1} = I_t + (1-\delta) K_t$.

SS: $I = \delta K$.

LL: $\hat{K}_{t+1} = \delta \hat{I}_t + (1-\delta)\hat{K}_t$.

Capital mobility condition:

Eq: $r_t = r_t^* + \kappa_t (M_t k_t - K_t)$.

SS: $r = r^* + \kappa (Mk - K)$.

LL: $r\hat{r}_t = r^* \hat{r}_t^* + \kappa Mk\left(\hat{\kappa}_t + \hat{M}_t + \hat{k}_t\right) - \kappa K\left(\hat{\kappa}_t + \hat{K}_t\right)$.

Euler equation:

Eq: $\xi_{ct} C_t^{-\alpha_c} = \beta E_t\left[\xi_{ct+1} C_{t+1}^{-\alpha_c}\left(1 + r_{t+1}^* - \delta - \kappa_{t+1} M_{t+1} k_{t+1}\right)\right]$.

SS: $1 = \beta\left(1 + r^* - \delta - \kappa Mk\right)$.

LL: $\alpha_c\left(\hat{C}_{t+1} - \hat{C}_t\right) - \left(\hat{\xi}_{ct+1} - \hat{\xi}_{ct}\right) = \beta\left\{r^* \hat{r}^*_{t+1} - \kappa Mk\left(\hat{\kappa}_{t+1} + \hat{M}_{t+1} + \hat{k}_{t+1}\right)\right\}$.

Final good:

Eq: $P_t Y_t = M_t p_t^d y_t^d + M_t^* \tau_t p_t^* y_t^*$.

SS: $PY = Mp^d y^d + M^* \tau p^* y^*$.

LL: $PY\left(\hat{P}_t + \hat{Y}_t\right) = Mp^d y^d\left(\hat{M}_t + \hat{p}_t^d + \hat{y}_t^d\right) + M^* \tau p^* y^*\left(\hat{M}_t^* + \hat{\tau}_t + \hat{p}_t^* + \hat{y}_t^*\right)$.

Firm level profit:

Eq: $\pi_t = \left(\dfrac{p_t^d}{P_t}\right) z_t - p_{at} a_t$.

SS: $\pi = \left(\dfrac{p^d}{P}\right) z - p_a a$.

LL: $\pi\pi_t = \left(\pi + p_a a\right)\left(\hat{p}_t^d - \hat{P}_t + \hat{z}_t\right) - p_a a\left(\hat{p}_{at} + \hat{a}_t\right).$

Demand for domestic intermediate varieties:

Eq: $y_t^d = M_t^{\lambda-1} Y_t \left(\frac{p_t^d}{P_t}\right)^{-\sigma}.$

SS: $y^d = M^{\lambda-1} Y \left(\frac{p^d}{P}\right)^{-\sigma}.$

LL: $\hat{y}_t^d = \left(\lambda - 1\right)\hat{M}_t + \hat{Y}_t - \sigma\left(\hat{p}_t^d - \hat{P}_t\right).$

Demand for foreign intermediate varieties:

Eq: $y_t^* = M_t^{*\lambda-1} Y_t \left(\frac{\tau_t p_t^*}{P_t}\right)^{-\sigma}.$

SS: $y^* = M^{*\lambda-1} Y \left(\frac{\tau p^*}{P}\right)^{-\sigma}.$

LL: $\hat{y}_t^* = \left(\lambda - 1\right)\hat{M}_t^* + \hat{Y}_t - \sigma\left(\hat{\tau}_t + \hat{p}_t^* - \hat{P}_t\right).$

Export:

Eq: $y_t^x = M_t^{\lambda-1} F_t^* \left(\frac{\tau_t p_t^d}{P_t^*}\right)^{-\sigma}.$

SS: $y^x = M^{\lambda-1} F^* \left(\frac{\tau p^d}{P^*}\right)^{-\sigma}.$

LL: $\hat{y}_t^x = \left(\lambda - 1\right)\hat{M}_t + \hat{F}_t^* - \sigma\left(\hat{\tau}_t + \hat{p}_t^d - \hat{P}_t^*\right).$

Labour demand and supply:

Eq: $\tilde{h}_t = \frac{e_t}{\alpha_f} h_t^{\alpha_f}.$

SS: $\tilde{h} = \frac{e}{\alpha_f} h^{\alpha_f}.$

LL: $\hat{\tilde{h}}_t = \hat{e}_t + \alpha_f \hat{h}_t.$

Labour demand and supply:

Eq: $N_t \tilde{h}_t = M_t l_t.$

SS: $N\tilde{h} = Ml.$

LL: $\hat{N}_t + \hat{\tilde{h}}_t = \hat{M}_t + \hat{l}_t.$

Aggregate intermediate goods:

Eq: $z_t = y_t^d + \tau_t y_t^x.$

SS: $z = y^d + \tau y^x.$

LL: $zz_t = y^d \hat{y}_t^d + \tau y^x \left(\hat{\tau}_t + \hat{y}_t^x\right).$

Marginal Cost:

Eq: $p_{at} = r_t^{(1-\gamma)} \tilde{w}_t^{\gamma}$.

SS: $p_a = r^{(1-\gamma)} \tilde{w}^{\gamma}$.

LL: $\hat{p}_{at} = (1-\gamma)\hat{r}_t + \gamma \hat{\tilde{w}}_t$.

Intermediate output:

Eq: $z_t = \varphi_t a_t$.

SS: $z = \varphi a$.

LL: $\hat{z}_t = \hat{\varphi}_t + \hat{a}_t$.

Marginal Product of labour:

Eq: $\tilde{w}_t l_t = \gamma p_{at} a_t$.

SS: $\tilde{w} l = \gamma p_a a$.

LL: $\hat{\tilde{w}}_t + \hat{l}_t = \hat{p}_{at} + \hat{a}_t$.

Marginal product of capital:

Eq: $r_t k_t = (1-\gamma) p_{at} a_t$.

SS: $rk = (1-\gamma) p_a a$.

LL: $\hat{r}_t + \hat{k}_t = \hat{p}_{at} + \hat{a}_t$.

Optimal real price:

Eq: $\frac{p_t^d}{P_t} = \frac{\sigma p_{at}}{(\sigma-1)\varphi_t}$.

SS: $\frac{p^d}{P} = \frac{\sigma p_a}{(\sigma-1)\varphi}$.

LL: $\hat{p}_t^d - \hat{P}_t = \hat{p}_{at} - \hat{\varphi}_t$.

Aggregate matches:

Eq: $\mathfrak{M}_t = \chi U_t^{\mu} V_t^{1-\mu}$.

SS: $\mathfrak{M} = \chi U^{\mu} V^{1-\mu}$.

LL: $\hat{\mathfrak{M}}_t = \mu \hat{U}_t + (1-\mu)\hat{V}_t$.

Market tightness:

Eq: $\theta_t = V_t / U_t$.

SS: $\theta = V/U$.

LL: $\hat{\theta}_t = \hat{V}_t - \hat{U}_t$.

Labour market transition probabilities:

Eq: $q_t^f = \chi \theta_t^{-\mu}$.

SS: $q^f = \chi \theta^{-\mu}$.

LL: $\hat{q}_t^f = -\mu \hat{\theta}_t$.

Eq: $q_t^w = \chi \theta_t^{1-\mu}$.

SS: $q^w = \chi \theta^{1-\mu}$.

LL: $\hat{q}_t^w = (1-\mu)\hat{\theta}_t$.

Aggregate employment (extensive margin):

Eq: $N_t = (1-\eta) N_{t-1} + \mathfrak{M}_t$.

SS: $\eta N = \mathfrak{M}$.

LL: $N\hat{N}_t = (1-\eta) N\hat{N}_{t-1} + \mathfrak{M}.\hat{\mathfrak{M}}_t$.

Aggregate unemployment:

Eq: $U_t = 1-(1-\eta) N_{t-1}$.

SS: $U = 1-(1-\eta) N$.

LL: $U\hat{U}_t = -(1-\eta) N\hat{N}_{t-1}$.

Vacancy creation condition:

$$\text{Eq: } \frac{(1-\zeta_t^V)x^V}{q_t^f} = \tilde{w}_t\tilde{h}_t - w_t h_t - (1-\zeta_t^T)x^T - \eta f_t + (1-\eta)E_t\beta\left(\frac{\xi_{ct+1}C_{t+1}^{-\alpha_c}}{\xi_{ct}C_t^{-\alpha_c}}\right)\frac{(1-\zeta_{t+1}^V)x^V}{q_{t+1}^f}.$$

$$\text{SS: } (1-(1-\eta)\beta)(1-\zeta^V)x^V = q^f\left(\tilde{w}\tilde{h} - wh - (1-\zeta^T)x^T - \eta f\right).$$

$$\text{LL:} -\left\{\frac{\zeta^V\hat{\zeta}_t^V}{(1-\zeta^V)} + \hat{q}_t^f\right\} = \left\{\tilde{w}\tilde{h}\left(\hat{\tilde{w}}_t + \hat{\tilde{h}}_t\right) - wh\left(\hat{w}_t + \hat{h}_t\right) + x^T\zeta^T\hat{\zeta}_t^T - \eta f\hat{f}_t\right\}$$
$$-\frac{(1-\eta)\beta(1-\zeta^V)x^V}{q^f}\left\{\hat{\xi}_{ct} - \hat{\xi}_{ct+1} + \alpha_c\left(C_{t+1} - C_t\right) + \frac{\zeta^V\hat{\zeta}_{t+1}^V}{(1-\bar{\zeta}^V)} + \hat{q}_{t+1}^f\right\}.$$

Wage bill:

$$\text{Eq: } w_t h_t = \Phi\left[\tilde{w}_t\tilde{h}_t - (1-\zeta_t^T)x^T - \eta f_t + (1-\eta)E_t\beta\left(\frac{\xi_{ct+1}C_{t+1}^{-\alpha_c}}{\xi_{ct}C_t^{-\alpha_c}}\right)(1-\zeta_{t+1}^V)x^V\theta_{t+1}\right]$$
$$+(1-\Phi)\left[b_t + \frac{\alpha_f\tilde{w}_t\tilde{h}_t}{(1+\alpha_h)}\right].$$

$$\text{SS: } wh = \Phi\left[\tilde{w}\tilde{h} - (1-\zeta^T)x^T - \eta f + (1-\eta)\beta(1-\zeta^V)x^V\theta\right] + (1-\Phi)\left[b + \frac{\alpha_f\tilde{w}\tilde{h}}{(1+\alpha_h)}\right].$$

$$\text{LL: } wh\left(\hat{w}_t + \hat{h}_t\right) = \Phi\left\{\tilde{w}\tilde{h}\left(\hat{\tilde{w}}_t + \hat{\tilde{h}}_t\right) + x^T\zeta^T\hat{\zeta}_t^T - \eta f\hat{f}_t\right\}$$
$$+\Theta\left\{\hat{\xi}_{ct+1} - \hat{\xi}_{ct} - \alpha_c\left(\hat{C}_{t+1} - \hat{C}_t\right) + \hat{\theta}_{t+1} - \frac{\bar{\zeta}^V\hat{\zeta}_{t+1}^V}{(1-\bar{\zeta}^V)}\right\} + (1-\Phi)\left\{b\hat{b}_t + \frac{\alpha_f\tilde{w}\tilde{h}\left(\hat{\tilde{w}}_t + \hat{\tilde{h}}_t\right)}{(1+\alpha_h)}\right\}.$$

where $\Theta = \Phi(1-\eta)\beta(1-\zeta^V)x^V\theta$.

Optimal hours per worker:

Eq: $Ah_t^{1+\alpha_h} = \xi_{ct} C_t^{-\alpha_c} \alpha_f \tilde{w}_t \tilde{h}_t.$

SS: $Ah^{1+\alpha_h} = \xi_c C^{-\alpha_c} \alpha_f \tilde{w} \tilde{h}.$

LL: $(1+\alpha_h)\hat{h}_t = \hat{\xi}_{ct} - \alpha_c \hat{C}_t + \hat{\tilde{w}}_t + \hat{\tilde{h}}_t.$

Government budget:

Eq: $T_t + N_t\left(\tilde{w}_t \tilde{h}_t - w_t h_t - x^T\right) - x^V V_t = (1-N_t) b_t.$

SS: $T + N\left(\tilde{w}\tilde{h} - wh - x^T\right) - x^V V = (1-N) b.$

LL: $T\hat{T}_t + N\tilde{w}\tilde{h}\left(\hat{N}_t + \hat{\tilde{w}}_t + \hat{\tilde{h}}_t\right) - Nwh\left(\hat{N}_t + \hat{w}_t + \hat{h}_t\right)$

$- x^T N\hat{N}_t - x^V V\hat{V}_t = (1-N) b\hat{b}_t - bN\hat{N}_t.$

Trade balance:

Eq: $\dfrac{M_t \tau_t p_t^d y_t^x}{P_t} - \dfrac{M_t^* \tau_t p_t^* y_t^*}{P_t} = r_t^*\left(M_t k_t - K_t\right).$

SS: $\dfrac{M \tau p^d y^x}{P} - \dfrac{M^* \tau p^* y^*}{P} = r^*\left(Mk - K\right).$

LL: $\dfrac{M \tau p^d y^x}{P}\left(\hat{M}_t + \hat{\tau}_t + \hat{p}_t^d + \hat{y}_t^x - \hat{P}_t\right)$

$-\dfrac{M^* \tau p^* y^*}{P}\left(\hat{M}_t^* + \hat{\tau}_t + \hat{p}_t^* + \hat{y}_t^* - \hat{P}_t\right) = r^* Mk\left(\hat{r}_t^* + \hat{M}_t + \hat{k}_t\right) - r^* K\left(\hat{r}_t^* + \hat{K}_t\right).$

Gross Domestic Product:

Eq: $GDP_t = Y_t + r_t^*\left(M_t k_t - K_t\right).$

SS: $GDP = Y + r_t^*\left(M_t k_t - K_t\right).$

LL: $GDPGDP_t = YY_t + r^* Mk\left(\hat{r}_t^* + \hat{M}_t + \hat{k}_t\right) - r^* K\left(\hat{r}_t^* + \hat{K}_t\right).$

Other exogenous variables take the form

$$\ln \Upsilon_t = \rho_\Upsilon \ln \Upsilon_t + \psi_{\Upsilon t},\ \Upsilon = \tau_t, \kappa_t, M_t, \xi_{ct}, \varphi_t, M_t^*, F_t^*, r_t^*, p_t^*, P_t^*, b_t, \zeta_t^V, \zeta_t^T.$$

Additional Variables

Trade deficit/surplus:

Eq: $TD_t = r_t^*\left(Mk_t - K_t\right).$

SS: $TD = r^*\left(Mk - K\right).$

LL: $TD_t = Mr^* k\left(\hat{M}_t + \hat{r}_t^* + \hat{k}_t\right) - r^* K\left(\hat{r}_t^* + \hat{K}_t\right).$

Match Value:

Eq: $J_t = \tilde{w}_t \tilde{h}_t - w_t h_t - \left(1-\zeta_t^T\right) x^T - \eta f_t + (1-\eta) E_t \Omega_{t+s} \dfrac{\left(1-\zeta_{t+1}^V\right) x^V}{q_{t+1}^f}.$

SS: $$J = \tilde{w}\tilde{h} - wh - \left(1-\zeta^{T}\right)x^{T} - \eta f + \frac{(1-\eta)\beta\left(1-\zeta^{V}\right)x^{V}}{q^{f}}.$$

LL: $$J\hat{J}_{t} = \tilde{w}\tilde{h}\left(\hat{\tilde{w}}_{t} + \hat{\tilde{h}}_{t}\right) - wh\left(\hat{w}_{t} + \hat{h}_{t}\right) + x^{T}\zeta^{T}\hat{\zeta}_{t}^{T} - \eta f\hat{f}_{t}$$

$$+\frac{(1-\eta)\beta\left(1-\zeta^{V}\right)x^{V}}{q^{f}}\left\{\hat{\xi}_{ct+1} - \hat{\xi}_{ct} - \alpha_{c}\left(C_{t+1} - C_{t}\right) - \frac{\bar{\zeta}^{V}\hat{\zeta}_{t+1}^{V}}{\left(1-\bar{\zeta}^{V}\right)} - \hat{q}_{t+1}^{f}\right\}.$$

4C Tables and Figures

Table 4.1: Baseline calibration

Parameter	Description	Value
α_c	relative risk aversion	0.8
α_f	production elasticity of working hours	0.995
α_h	frisch elasticity	2
β	subjective discount factor	0.996
δ	depreciation rate	0.025
λ	importance of variety measure	0
$F^* = P^* = \xi_c$	normalisation (see text)	1
τ	iceberg trade cost	1.3
σ	demand elasticity: set to target $M\pi/GDP = 0.2$	6
$r = r^*$	interest rate	0.05
κ	capital mobility coefficient: set to target $I/GDP = 0.17$	0.00088
Φ	bargaining power/trade union	0.5
μ	matching elasticity (Hosios condition)	$1 - \Phi$
η	job separation rate	0.038
γ	elasticity of output to labour input: targets $Nwh/GDP = 0.57$	0.7144
x^V	vacancy creation cost (implied from the steady state)	0.3225
x^T	training cost (implied from the steady state)	0.006
χ	Matching efficiency (implied from the steady state)	0.4865
M, M^*	number of domestic and foreign varieties	1, 10
A	disutility of work measure: set to target $h = 0.424$	10
φ	TFP parameter: set to target $GDP = 1$	0.751
ρ_b	UI replacement rate	0.38
ρ_f	firing cost ratio	0.063
$\zeta^T = \zeta^V$	subsidies	0
e	measure of effort	0.7
p^*	Price of imported varieties (derived from the steady state)	1.009

Note: the sources of the parameter values are discussed in the text, section 4.4.

Table 4.2: Effects of liberalisation on the steady state economy

Variable	Scenario (i) Pre-Lib (Baseline)	Scenario (ii) Partial Lib (Capital, $\kappa\downarrow$)	Scenario (iii) Partial Lib (Trade, $\tau\downarrow$)	Scenario (iv) Absolute Lib ($\kappa\downarrow$ & $\tau\downarrow$)
GDP	1.0000	1.0821	1.1119	1.1903
C	0.8073	0.9129	0.8736	0.9770
K	6.8000	15.1769	2.3503	10.8738
J	0.9146	0.9536	0.9674	1.0028
θ	0.4830	0.5251	0.5403	0.5806
N	0.9308	0.9348	0.9361	0.9394
U	0.1046	0.1008	0.0995	0.0963
w	1.4433	1.5704	1.5799	1.7020
p^d	1.0336	1.1053	1.0651	1.0810
y^d	0.7274	0.8604	0.3977	0.5054
y^*	0.0174	0.0308	0.0435	0.0604
y^x	0.1699	0.1136	0.5413	0.4952
π	0.1667	0.1804	0.1853	0.1984

Table 4.3: Steady state solution and policy comparative statics

Var.	Baseline	LM-Reforms				ALMPs	
		$\rho_b\downarrow$	$\rho_f\downarrow$	$x^T\downarrow$	$x^V\downarrow$	$\zeta^T\uparrow$	$\zeta^V\uparrow$
GDP	1.00000	1.00611	1.00003	0.99983	1.00508	1.00007	1.00287
C	0.80727	0.80855	0.80728	0.80843	0.81170	0.80729	0.80793
K	6.80000	6.55694	6.79888	6.80675	6.59791	6.79732	6.68599
J	0.91462	1.03324	0.91511	0.91684	0.82324	0.91580	0.87053
θ	0.48300	0.61641	0.48352	0.48534	0.61142	0.48425	0.54019
N	0.93076	0.94207	0.93081	0.93099	0.94171	0.93088	0.93609
U	0.10461	0.09373	0.10456	0.10438	0.09407	0.10449	0.09948
w	1.44334	1.43197	1.44398	1.44667	1.44317	1.44488	1.44291
$\tilde{w}$	2.13511	2.12747	2.13507	2.13532	2.12875	2.13502	2.13151
p_a	0.65997	0.65943	0.65997	0.65998	0.65952	0.65996	0.65971
p^d	1.03358	1.02992	1.03356	1.03368	1.03053	1.03353	1.03186
y^d	0.72742	0.72926	0.72743	0.72737	0.72895	0.72744	0.72829
y^*	0.01741	0.01708	0.01741	0.01742	0.01714	0.01740	0.01725
y^x	0.16994	0.17359	0.16995	0.16984	0.17297	0.16998	0.17164

Table 4.4: Economic openness and labour market reforms

	Var.	Equilibrium after lib. (but before LM reform)	Labour Market Reform: Equilibrium with benefit (ρ_b) reform	Labour Market Reform: Equilibrium with firing (ρ_f)reform	ALMPs: Equilibrium with vacancy subsidy (ζ^V)	ALMPs: Equilibrium with training subsidy (ζ^T)
Capital liberalisation	GDP	1.08212	1.08822	1.08215	1.08498	1.08428
	C	0.91287	0.91405	0.91288	0.91349	0.91413
	K	15.17692	14.93446	15.17581	15.06317	15.09128
	θ	0.52505	0.66962	0.52562	0.58702	0.52738
	N	0.93476	0.94567	0.93481	0.93989	0.93496
	U	0.10076	0.09027	0.10072	0.09582	0.10056
	w	1.57041	1.55818	1.57111	1.56983	1.57451
	$\tilde{w}$	2.31873	2.31027	2.31869	2.31475	2.32232
	p_a	0.67179	0.67111	0.67179	0.67147	0.67291
	p^d	1.10528	1.10152	1.10526	1.10352	1.11143
	y^d	0.86044	0.86410	0.86046	0.86216	0.85131
	y^*	0.03079	0.03030	0.03079	0.03056	0.03150
	y^x	0.11363	0.11598	0.11364	0.11473	0.12090
Trade liberalisation	GDP	1.11188	1.11825	1.11191	1.11487	1.11943
	C	0.87358	0.87490	0.87359	0.87426	0.87804
	K	2.35033	2.09668	2.34916	2.23134	2.04971
	θ	0.54031	0.68911	0.54089	0.60408	0.54541
	N	0.93610	0.94688	0.93615	0.94118	0.93653
	U	0.09947	0.08910	0.09943	0.09459	0.09905
	w	1.57987	1.56800	1.58057	1.57943	1.59050
	$\tilde{w}$	2.33151	2.32351	2.33147	2.32775	2.34453
	p_a	0.72440	0.72381	0.72440	0.72412	0.72870
	p^d	1.06511	1.06342	1.06511	1.06432	1.07716
	y^d	0.39771	0.39863	0.39772	0.39815	0.38266
	y^*	0.04348	0.04317	0.04348	0.04333	0.04475
	y^x	0.54129	0.54646	0.54131	0.54371	0.55655

Figure 4.1: Baseline (positive) TFP shock

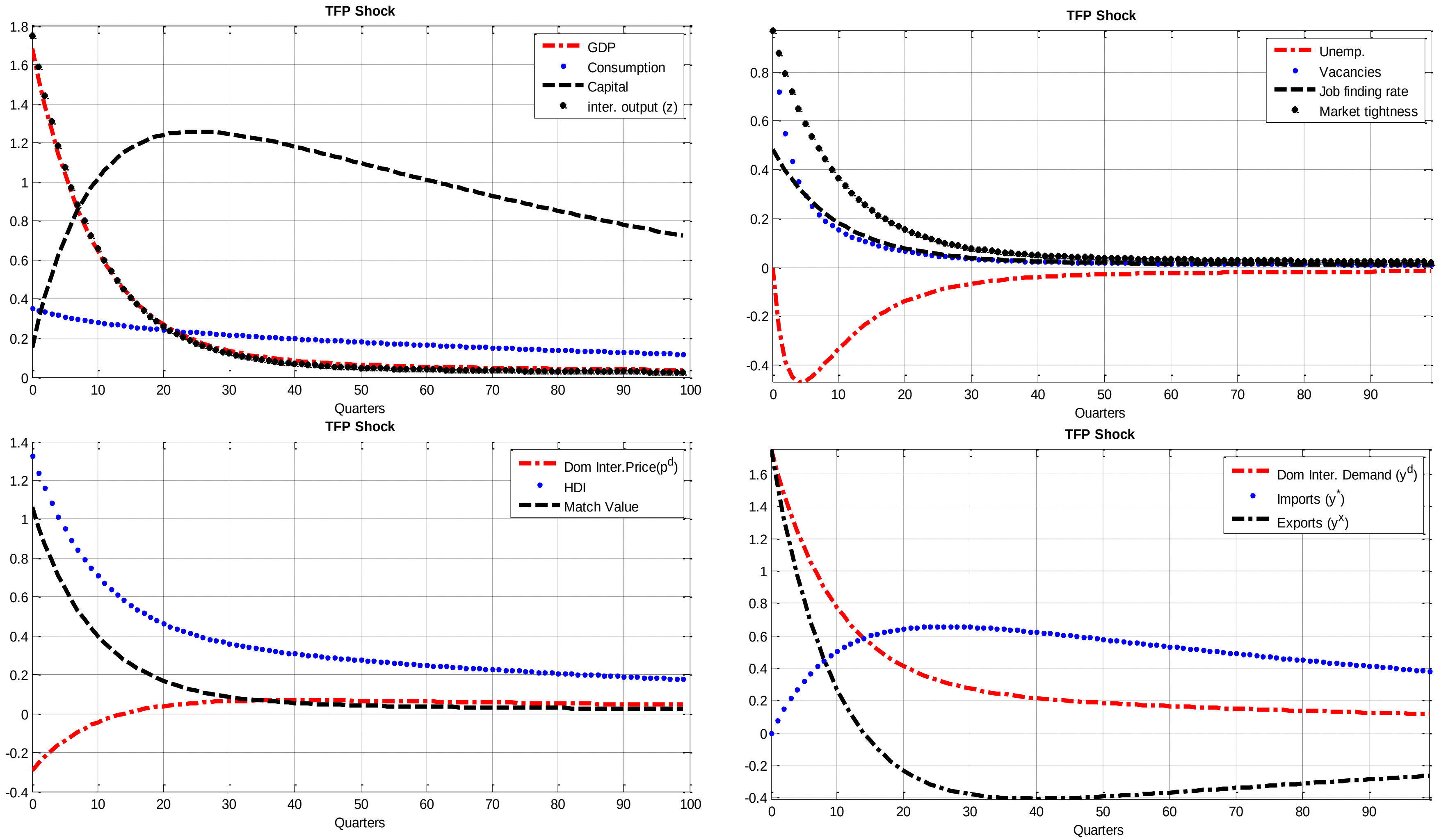


Figure 4.2: Baseline (positive) foreign demand shock

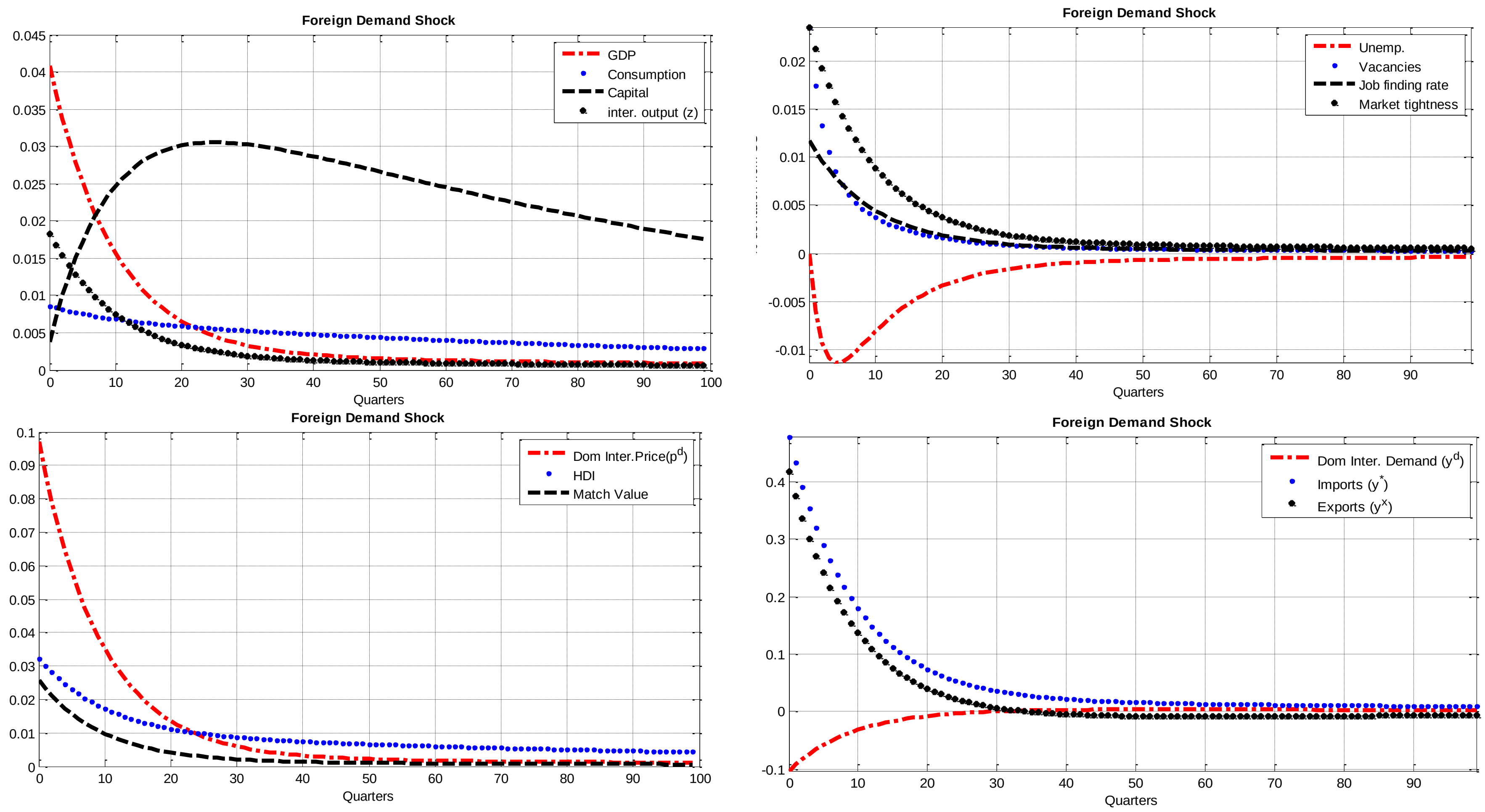


Figure 4.3: Partial liberalisation in capital (reduction in κ)

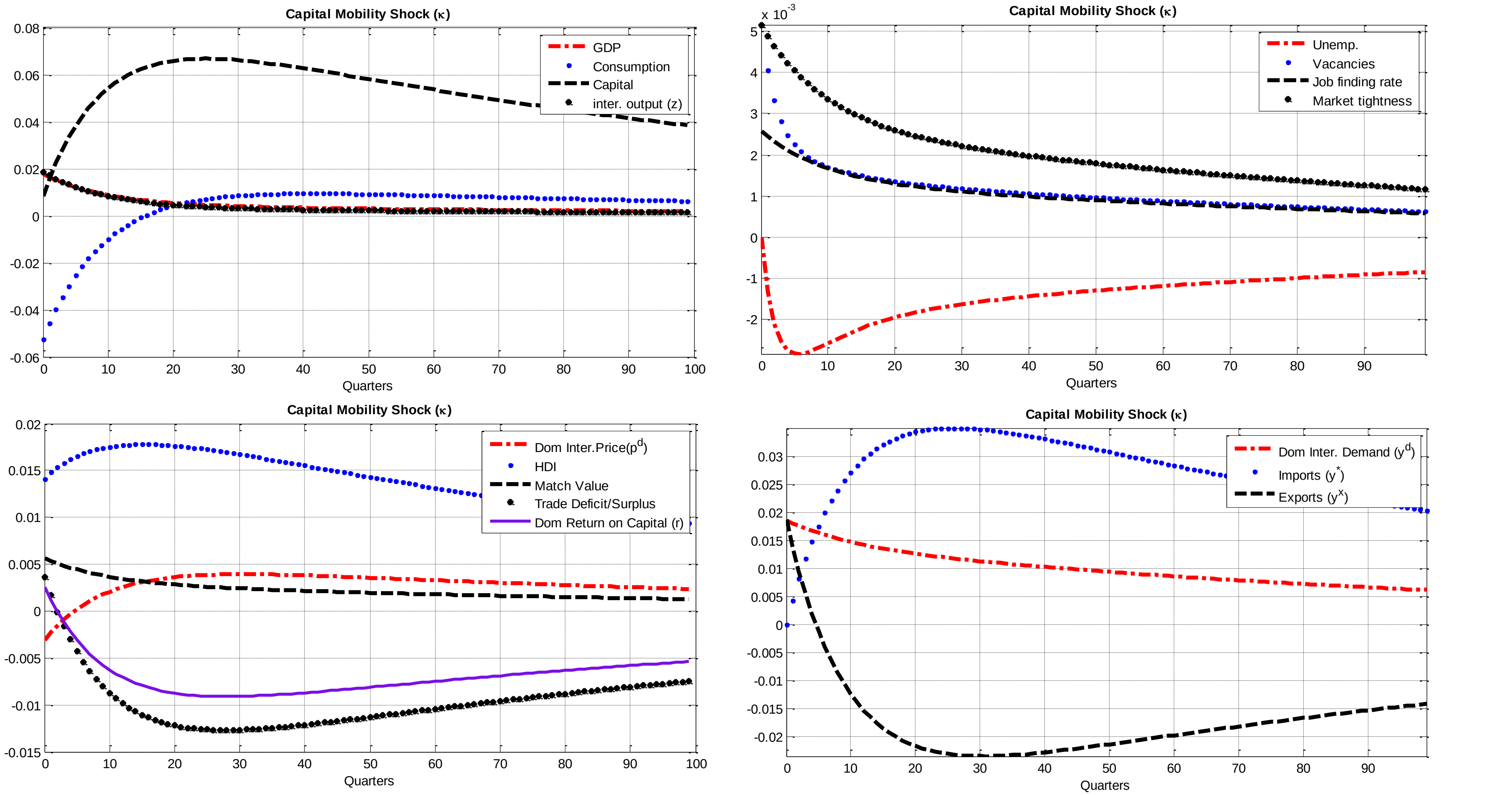


Figure 4.4: Partial liberalisation in trade (reduction in τ)

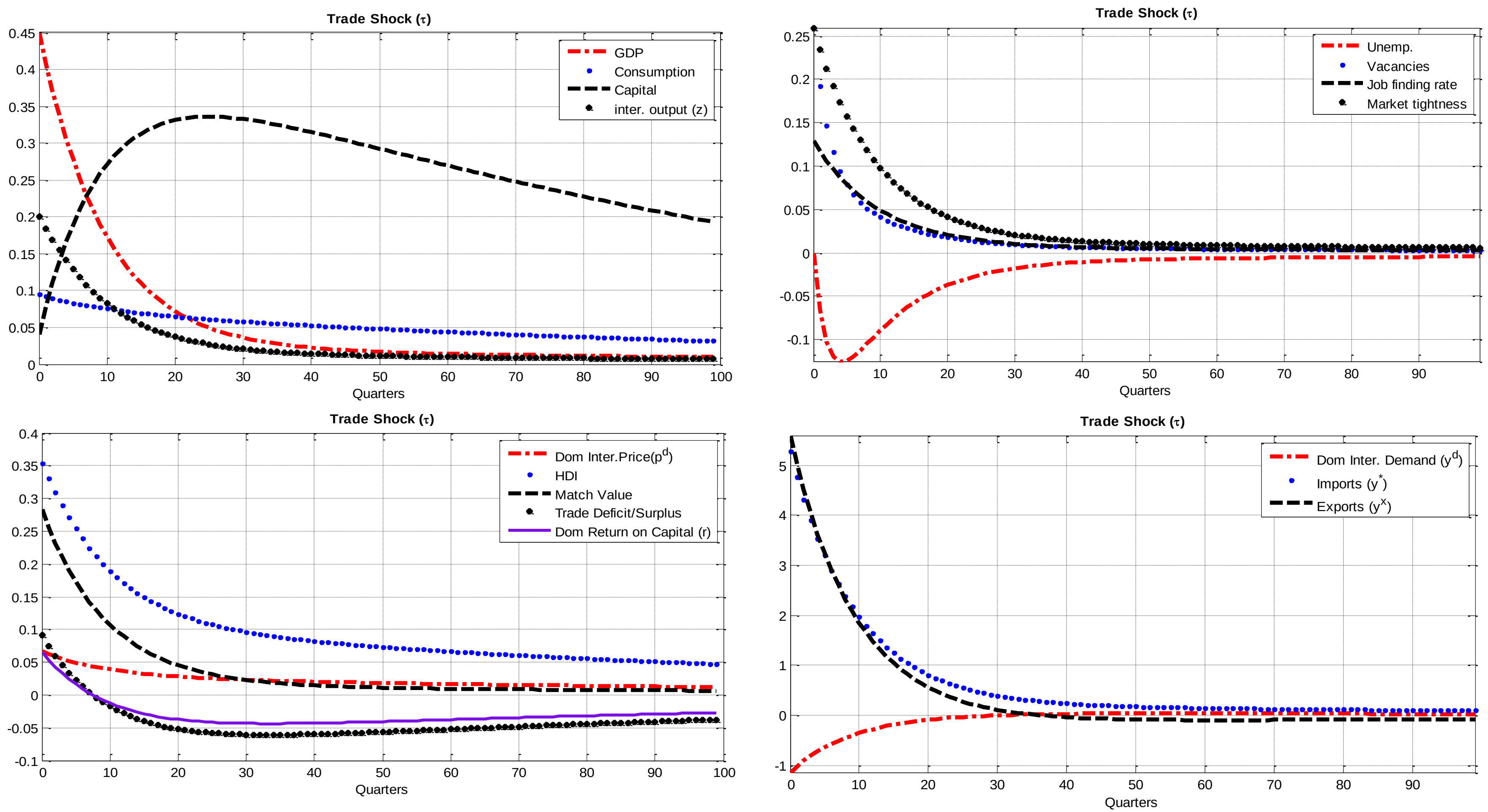


Figure 4.5: Economic openness and the adjustment of unemployment

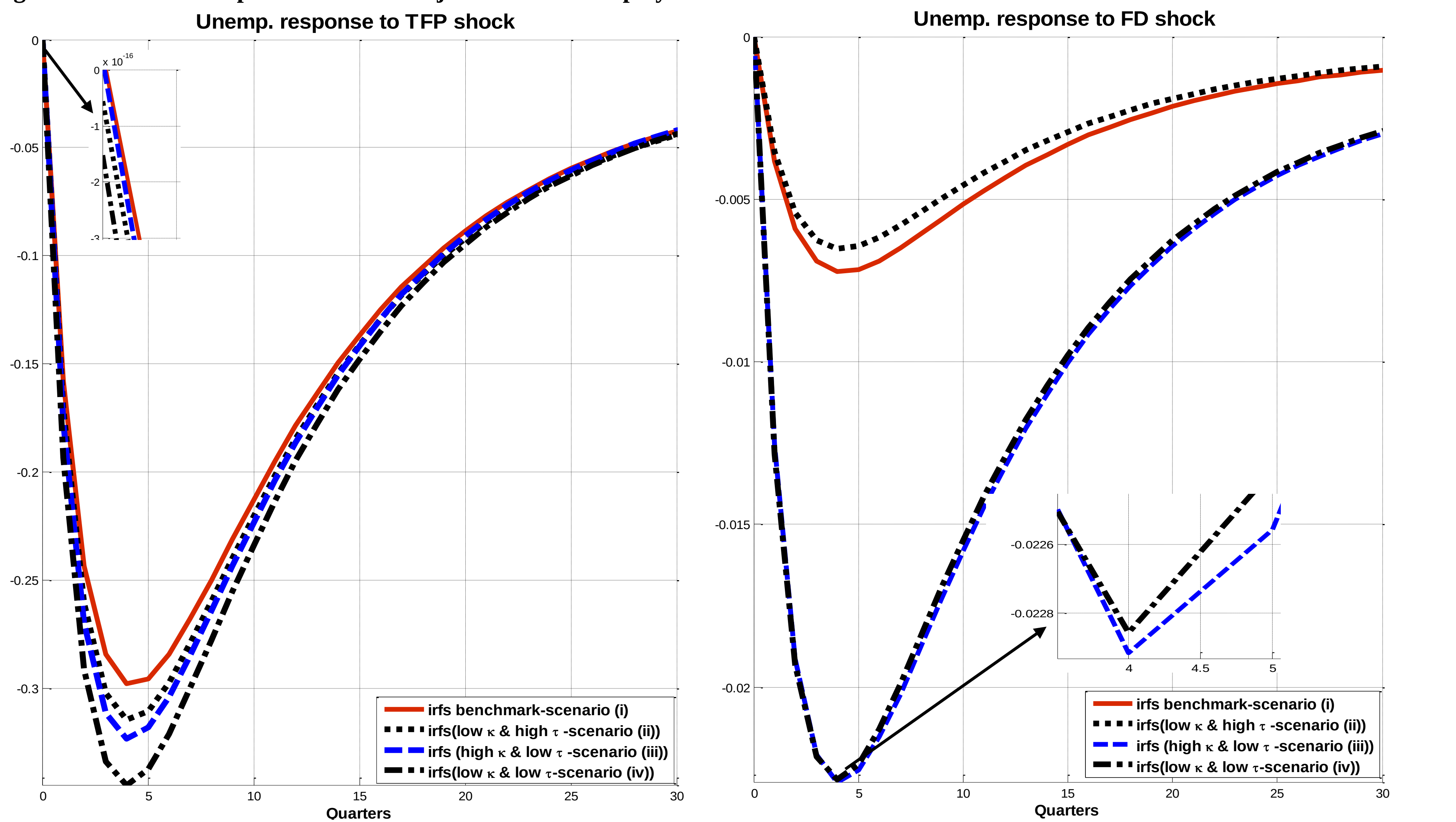


Figure 4.6: Effects of economic openness on the IRFs following a (positive) TFP shock

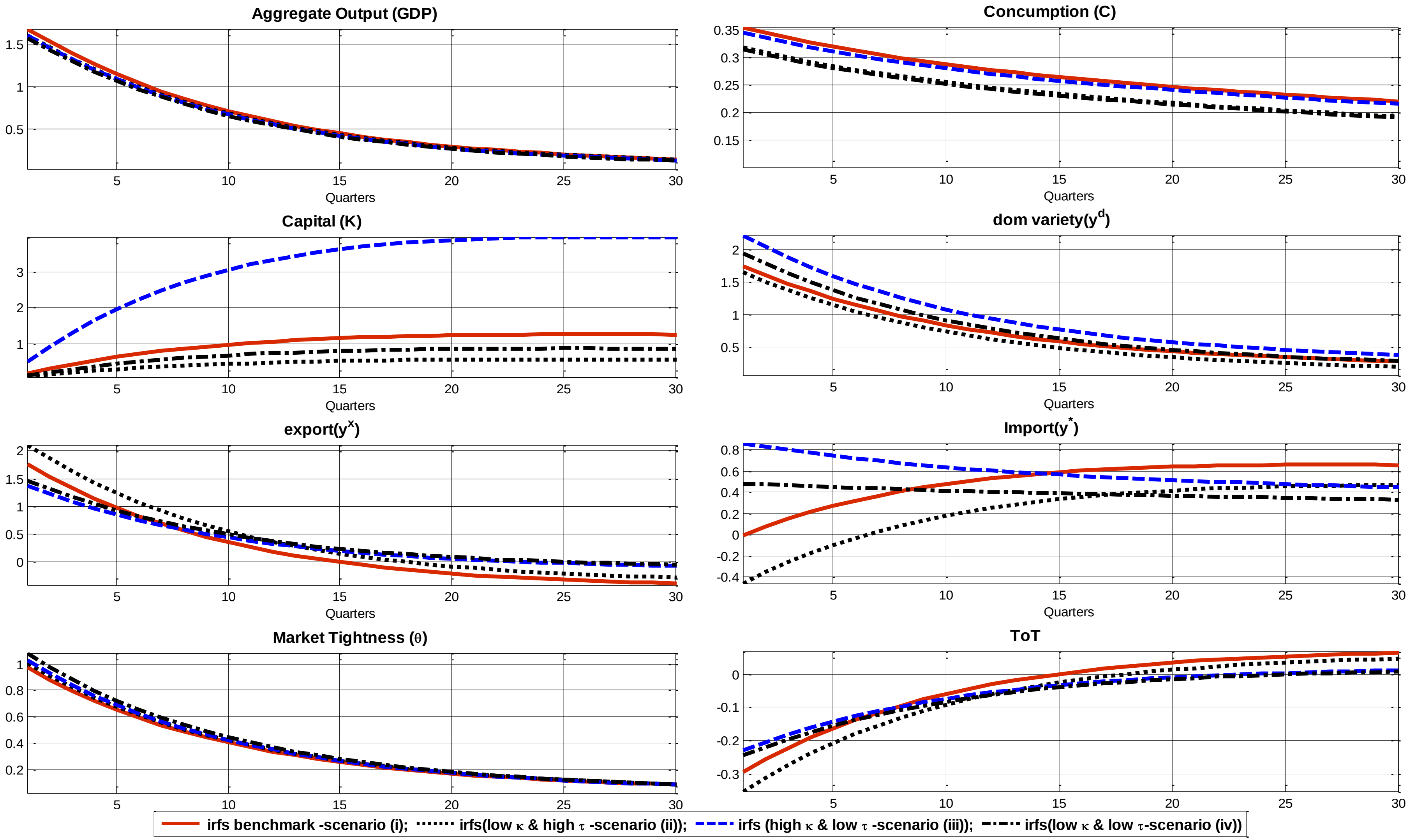


Figure 4.7: Effects of economic openness on the IRFs following a (positive) FD shock

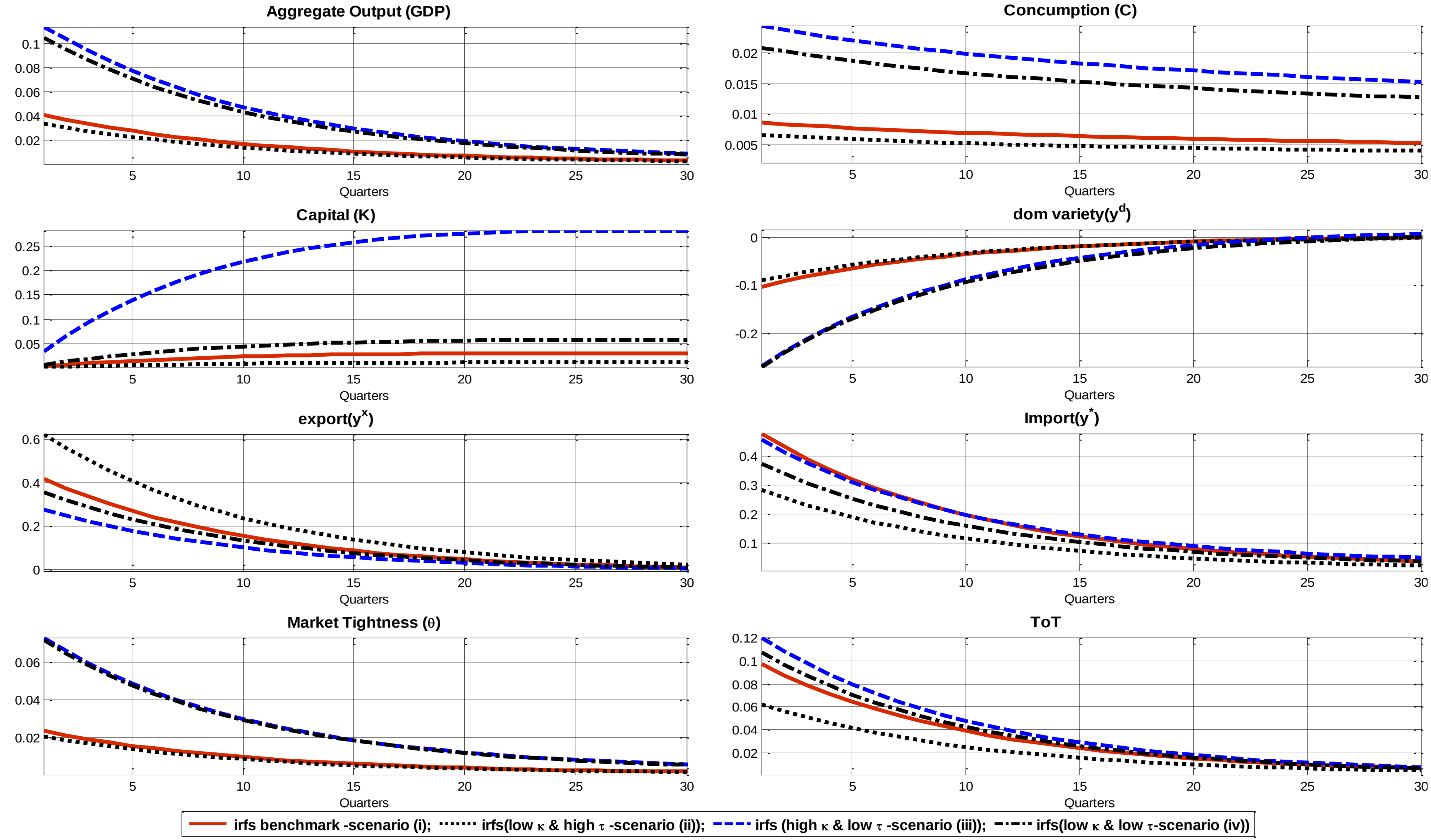


Figure 4.8: Welfare system and the response of unemployment

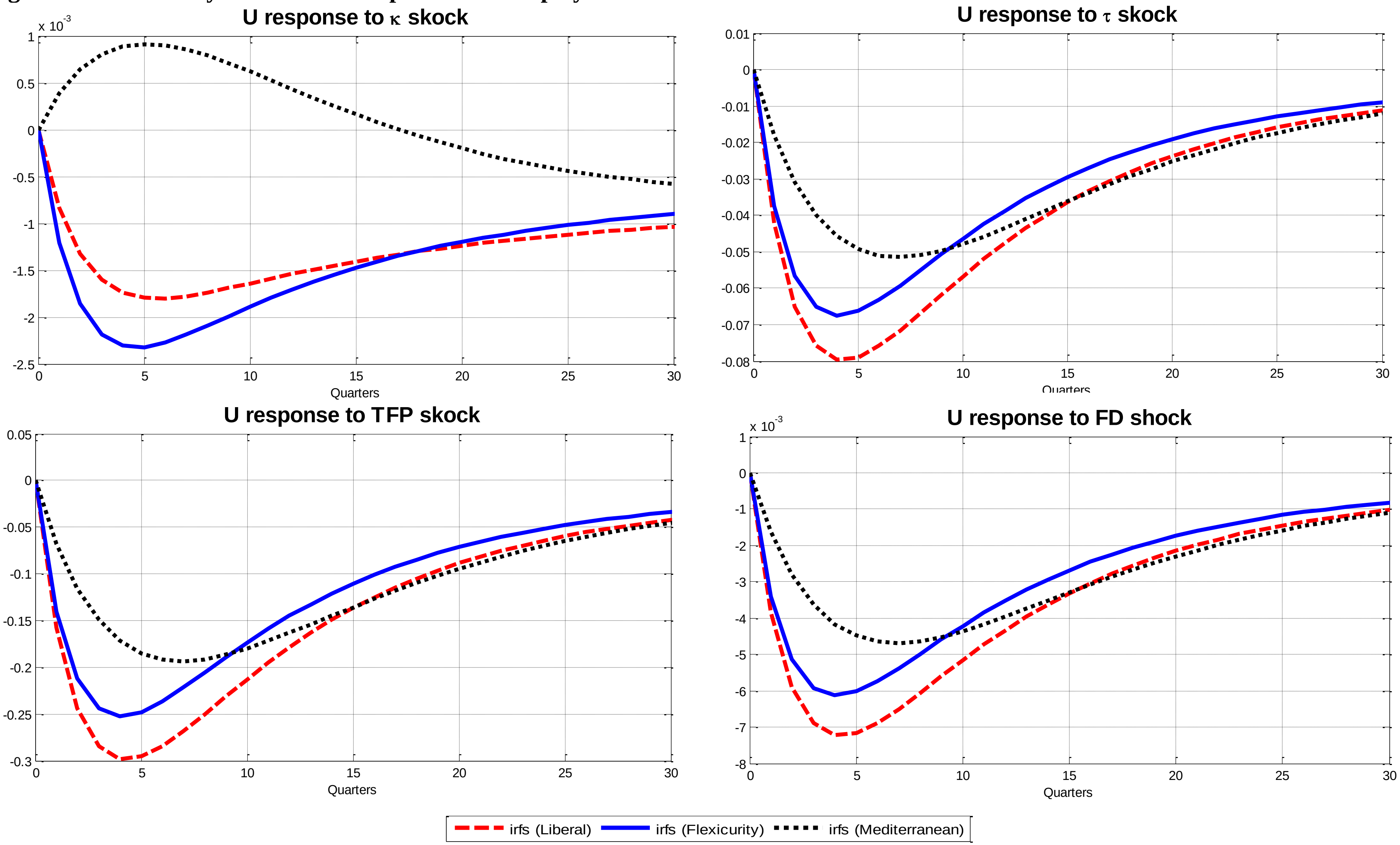


Figure 4.9: Positive training (ζ^T) and vacancy creation (ζ^V) subsidies

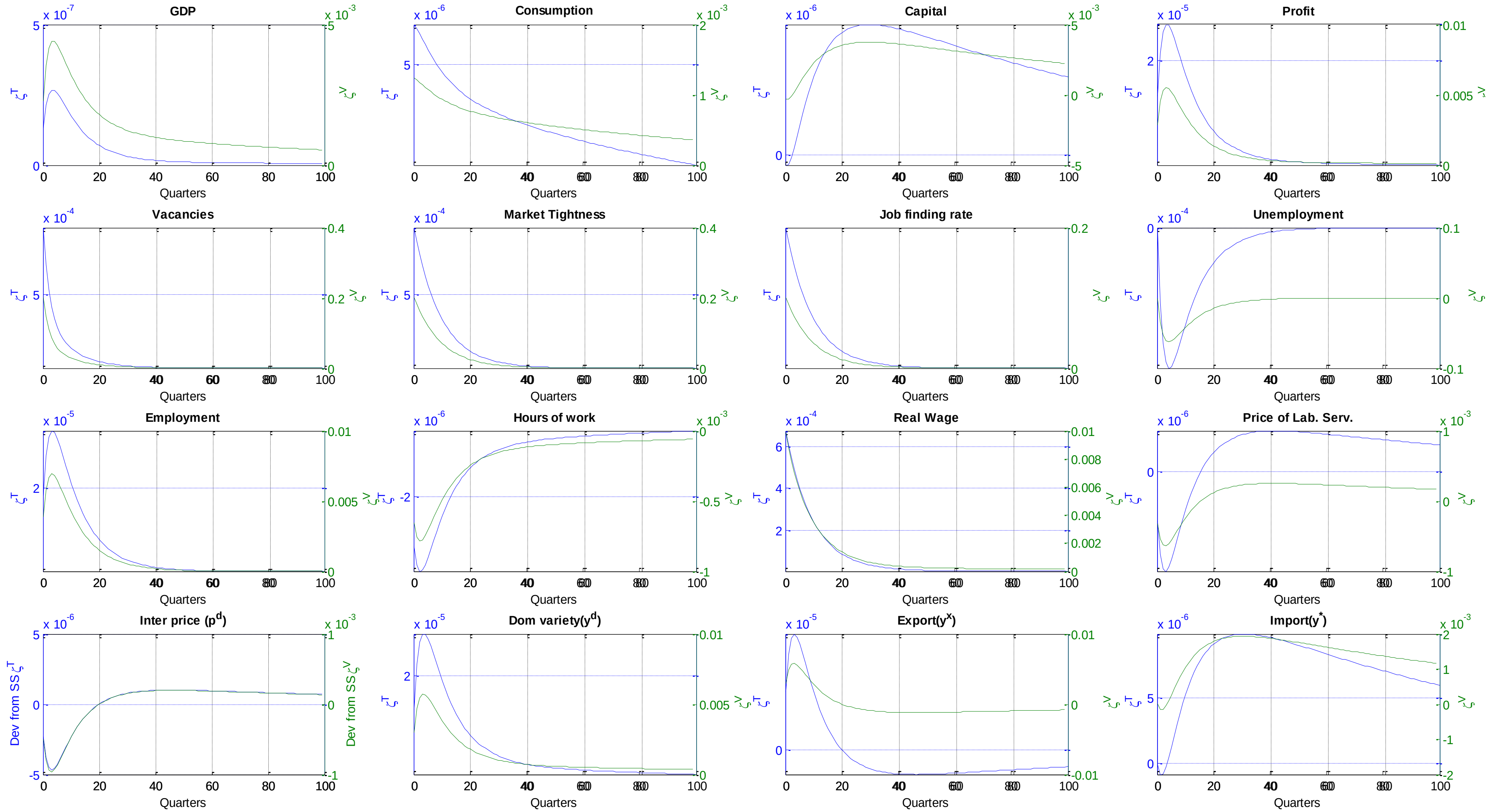
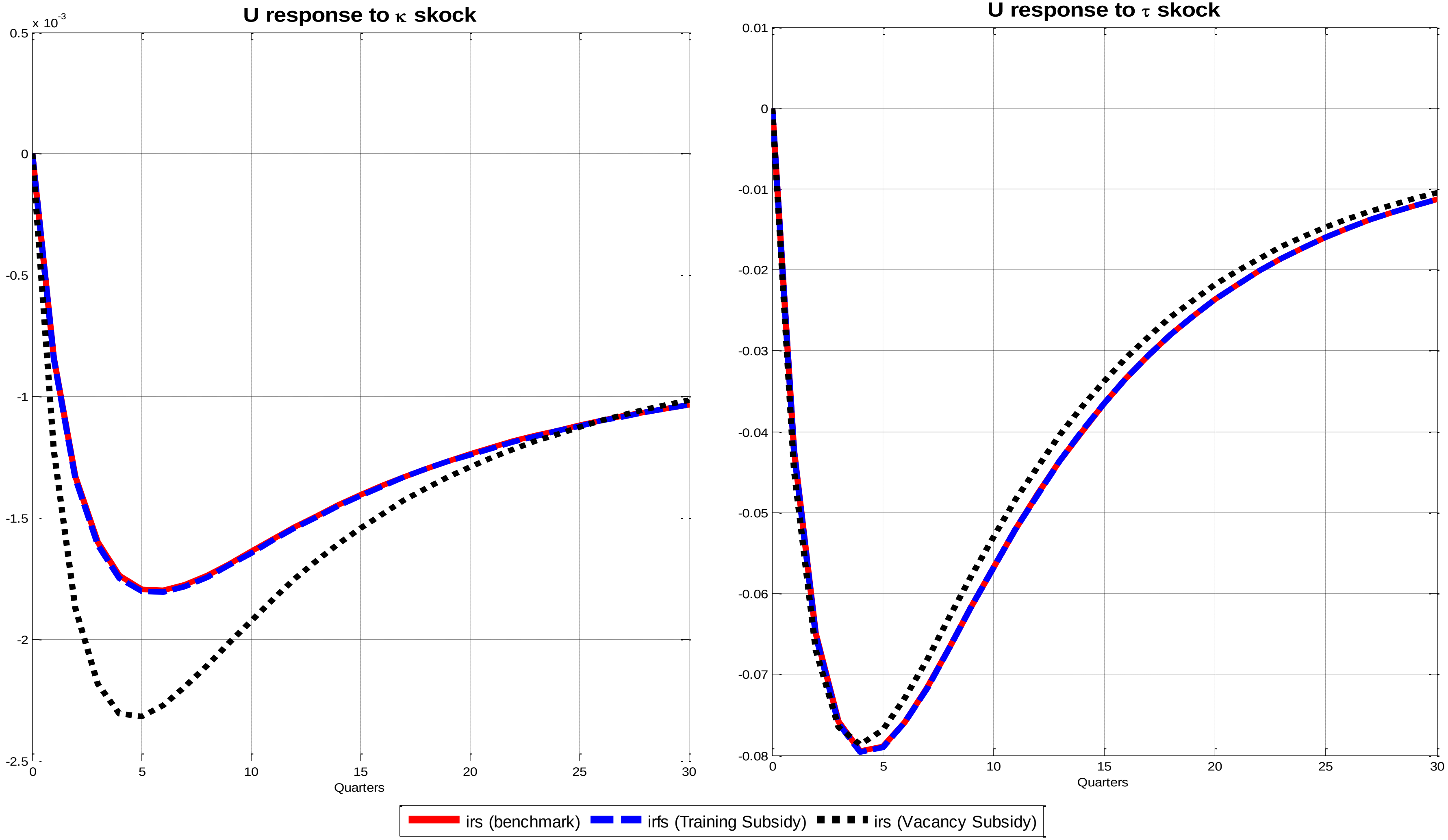


Figure 4.10: Effects of ALMPs on the adjustment of unemployment to trade and capital mobility shocks



Chapter 5. Conclusion

5.1 Summary and Conclusion

The thesis is composed of three main chapters that are broadly motivated by the labour market effects of the recent global economic crisis, and the role of active and passive labour market policies in shaping these effects. A key feature in each chapter is the presence of search and matching frictions in the labour market. The search and matching model allows for an easy characterisation of the labour market which enabled us to examine a wide range of issues addressed in this thesis. We contribute to the growing literature attempting to provide an understanding of the functioning of the labour market and the dynamics of unemployment.

In Chapter 2, we examined the effects of specific employment policies (consisting of targeted severance compensation and, a common, fixed firing cost and recruitment subsidy) on labour market outcomes. In particular, we studied how these policies drive firms' vacancy creation and allocation decisions and, consequently, the unemployment rates of skilled and unskilled workers. To achieve this, we modified the Albrecht and Vroman (2002) version of the search model with cross-skill matching equilibrium and jobs minimum skill requirement. This framework features heterogeneous skilled and unskilled workers and high- and low-tech jobs. Whilst workers' skills are exogenously distributed, vacancy creation and their allocation into job types are endogenously driven. A fundamental assumption is that skilled workers are suitable for any of the two job types, whereas unskilled workers are only suitable for low-tech jobs. This assumption, thus, gives the skilled in the labour force some leverage over their unskilled counterparts, reflecting existing labour market stylised facts. Our analysis is divided into two parts. In the first part, we assumed that a job match is established between a job-searching worker and a firm with a vacancy when they both meet and agree to a wage rate determined via Nash bargaining solution. In the second part, wages are assumed to be predetermined and are, therefore, taken as given when establishing job matches.

Using this framework, we show that labour market policies have different equilibrium effects depending on whether they are targeted or common to all job types. In particular, our results revealed that when directed towards low-tech jobs, an increase in severance compensation leads to lower vacancy creation and reduces the fraction of vacancies allocated towards low-tech job type. Unskilled workers are therefore worse off: our simulations showed that in all cases, the percentage increase in the unemployment rate of the unskilled is at least three times higher than the increase of skilled workers'. On the contrary, when directed toward high-tech jobs, severance compensation leaves vacancy creation decision unaffected but alters the allocation of vacant jobs in favour of low-tech job type, leading to lower unemployment rate of the unskilled. However, given that skilled workers are suitable for low-tech jobs also, their unemployment rate remains stable, suggesting labour crowding out effects. Fixed firing cost, assumed to be common to both job types, reduces vacancy creation activities and shifts allocation away from low-tech jobs and towards high-tech ones. This also leaves the unskilled worse off, but unlike targeted low-tech severance policy, the effect is minimal. Vacancy creation subsidy, also considered to be common to all firms, is found to improve labour market outcomes by making vacancies more available vis-a-vis lower job creation cost. While such a subsidy does shift the allocation of vacancies towards high-tech jobs, the ensuing reduction in the competition for low-tech jobs leads to improvement in the employment outcome of unskilled workers. Comparing these results with those obtained fixed wage framework, we observed similar qualitative effects. However, we found that the sensitivity of firms to changes in labour market policies are generally greater when wages are predetermined. Finally, this chapter offers new insight into how the effects of severance compensation on the labour market can be assessed theoretically. We show, against conventional wisdom, that as long as there is strict enforcement, severance compensation will have deep consequences on job creation and unemployment.

Chapter 3 of this thesis contributes to the literature exploring the labour market effects of fiscal policies. We studied the effects of labour market institutions on the structure of the economy and the way this alters the propagation of fiscal policy shocks. Thus, we developed a closed economy real business cycle DSGE model with two vertically integrated production sectors, a household and a government. An intermediate sector, consisting of a mass of monopolistically competitive firms, is assumed to produce intermediate goods, using labour and capital as input factors. Each of these firms creates vacancies at a fixed sunk cost in order to hire workers per period. Once employment relationships are established, wages and hours of work are negotiated between the firms and the employees. Thus, we capture employment both at extensive (number of workers) and intensive (hours per worker) margins. Job matches are assumed to be dissolved at a constant exogenous rate. A homogenous final output (used for government and household consumptions and for capital formation) is produced in a competitive final good sector, using intermediate goods as input. The representative household consumes final goods, saves its wealth in capital and supplies labour. The government operates a balanced budget and finances its expenditure using revenues generated through taxes on firms and the household and labour income. It spends on own consumption, which is assumed to be utility-enhancing as against wasteful expenditure, as well as on the provision of unemployment insurance benefits and active labour market policies (that consists of vacancy creation and employment tax subsidies).

We found that the labour market institutions matters for aggregate economic performance. Particularly, when associated with higher rigidity, labour market institutions (captured by a firing penalty, which in turn consists of severance compensation and a fixed firing cost, unemployment benefits and distortionary labour tax) amplify the effects of government consumption expenditure on vacancy creation, employment and hours of work. The initial sizes of the household budget and surplus of a job match are identified to play a major role in determining these effects. By raising the cost of labour to the firing firms, higher rigidity shrinks the size of match surplus and, consequently, the size of the household budget, making both firms and the household more sensitive shocks. The impact of government demand shock is therefore transmitted to the rest of the economy through a more rapid adjustment in vacancy creation activities, which amplifies the response of employment at extensive margin. Additionally, since government spending reduces household budget size via taxes required to satisfy a balanced budget, the anticipation of higher tax obligation leads to increased downward adjustment in investment and consumption, when the initial household budget is small. This, in turn, amplifies the response of hours supply. Hence, whilst investment is lowered as a result of negative wealth effect, the increase in aggregate hours of work sustains output level. Our results indicated that strict unemployment insurance benefits and distortionary labour tax policies play a key role in raising the sensitivity of firms and households compared to fixed firing tax and severance compensation.

Furthermore, we showed that while an expansion in government consumption spending does lead to a higher employment via its aggregate demand effect, the extent to which this occurs also depends on the degree of substitutability between public and private consumption. Specifically, we found that when associated with a higher weight in private utility, the magnitude of the impact of government consumption demand stimulus on employment drops. We then compare the effects of government consumption spending and labour market-oriented fiscal stimulus. Our model consistently indicates that only labour market-oriented policies (subsidies) could be more effective in fostering employment. In particular, we found that in the presence of labour market rigidities and regardless of the financing option, only a subsidy directed towards job creation can generate output and employment multipliers effects that are much larger than unity.

The final chapter (Chapter 4) contributes to the literature examining the labour market effects of globalisation. Here, we developed a small open economy DSGE framework with vertical linkages in the production sector and labour market intermediation. The economy is linked to the rest of the world through trade in intermediate goods and capital mobility, but *small* in the sense that the total aggregate demand for its exports, the price of the varieties it imports, and the world rate of return on capital cannot be influenced by the activities of domestic agents. We assumed a non-traded final good is produced using domestic and imported varieties by a perfectly competitive sector. The domestic varieties of the input, which are also exported, are produced by an intermediate sector characterised by monopolistic competition in the product market. This sector uses labour man-hours and capital as factor input in the production process. We modelled a hiring sector set up by the government to act as intermediary between the household (that supply labour) and the intermediate sector. The role of this sector is to hire and train unemployed members of the household whose services are subsequently sold competitively as labour man-hours. A representative household is assumed to have access to international capital market which it uses to deal with residual capital requirements in the domestic economy. Using this framework, we examined the influence of changes in the degree of openness to international trade (measured by *iceberg* trade cost) and capital mobility (modelled as the line proposed by Rodrik, 1998) on labour market outcomes, with emphasis on unemployment.

Using numerical examples, we showed that a reduction in the impediments to international capital mobility can lead to higher labour productivity, GDP and lower unemployment. We identified two key channels through which this impacts unemployment; namely, *domestic demand effect* and *wealth effect*. First, we argued that as long as capital is accumulated in the domestic economy, an increase in international capital mobility, by expanding investment opportunities, will result in a higher demand for domestic varieties, consequently leading to higher labour productivity and lower unemployment. Second, as domestic investment rises, the ensuing negative interest rate differential induces capital outflow which in turn creates positive wealth effect via a higher foreign return. This consequently leads to further domestic consumption and investment; thus, positively impacting labour productivity that results in lower unemployment. Regarding the effect of trade liberalisation, we found that by raising foreign demand for exported varieties, a lower trade impediment can also result in lower unemployment. In particular, we establish that when jointly implemented, higher openness to international trade and capital mobility will lead to a much more reduction in unemployment.

We went further to investigate how changes in the degree of economic openness alter the dynamics of unemployment in response to domestic productivity and foreign demand shocks. We found that a reduction in barriers to international capital mobility leads to higher volatility in unemployment in response to domestic productivity shock. Our model further reveals that this effect is greater the more open the economy is to international trade, thus adding to the literature which has so far concentrated on the individual effects of trade and capital mobility. In particular, it is shown that shocks originating from different sources will have different effects on the adjustment of unemployment, depending crucially on the degree of openness to international capital mobility. We found that whilst a higher degree of openness to capital mobility increases the responsiveness of unemployment to domestic productivity shock, it dampens the adjustment effect to foreign demand shock. By contrast, a lower international trade impediment magnifies the effects of both shocks on the dynamics of unemployment.

Finally, we examined how labour market structure shapes the behaviour of unemployment in response to shock. This was driven by the fact that the recent reform drive towards improving labour market flexibility, especially in the EU, have been justified on the grounds that a well-functioning market is required to mitigate the negative consequences of globalisation on job creation. We found that the heterogeneity in the labour market structure, as reflected in the differences in welfare systems, can have important implications on labour market's adjustments to shocks. In particular, using stylised calibrations, which can be thought as reflecting the *liberal*, *flexicurity* and the *Mediterranean* welfare state systems in the EU, we found that the ones characterised by higher flexibility (corresponding to flexicurity and liberal systems) exhibit greater volatility in unemployment in response to domestic and external shocks. By contrast, the Mediterranean system with high labour market rigidity produces a much slower and persistent response in unemployment.

5.2 Closing Remark

This thesis attempted to answer several pressing questions about labour market outcomes using different equilibrium set-ups. The results produced should, however, be treated with caution. This is, in part, due to the assumptions we made. While these are potentially desirable assumptions so as to keep our analysis manageable and tractable, the conclusions reached are likely to change (although this cannot be determined ex-ante) if some assumptions are relaxed. For example, throughout this thesis, we have assumed that job destruction rate is exogenously determined, with Chapters 3 and 4 further assuming that workers and firms are identical. Fujita and Ramey (2012) show that endogenous and exogenous job separation are likely to have different implications for the dynamics of unemployment in the models with search and matching frictions. For example, throughout our theoretical formulations, we have assumed that firms adjust to changes in labour market policies (such as fixed firing cost) by altering their vacancy creation activities. Zanetti (2011a) however shows that a higher fixed firing cost can induce firms to reduce both job creation and productivity threshold, which influences job destruction rate. The former yields the usual results found in this thesis: an increase in firing cost reduces the number of vacancies and increases unemployment. However, by lowering productivity threshold, the rate of job separation reduces as well. These results show that an increase in firing cost is thus likely to have an ambiguous effect on unemployment depending on its net effect on job creation and job destruction rates. Progress in this area, therefore, requires endogenising the job destruction rate.

Additionally, as we have already identified in Chapter 2, the unemployment rates for different categories of workers react differently to policy shocks. Another useful, extension in both Chapters 3 and 4 will be to introduce skill heterogeneity. In particular, in Chapter 4, there are concerns that globalisation may have asymmetric effects on workers with differences in skills in the area of work displacement (Brecher & Chen, 2010). Using heterogeneous firms' framework with varying productivities, Melitz (2003) shows that an increase in trade openness induces the larger and more productive firms to select into exporting, whereas the least productive ones contract or drop out of the market. While unemployment is ignored in that paper, the implication of that model is that higher openness to trade is likely to lead to uneven effects for workers with varying skills due to the expansion and contractions of firms with high and low productivity levels. Another interesting way of improving the models could be to introduce labour force participation. Brückner and Pappa (2012) show that this can have implications on the behaviour of unemployment.

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